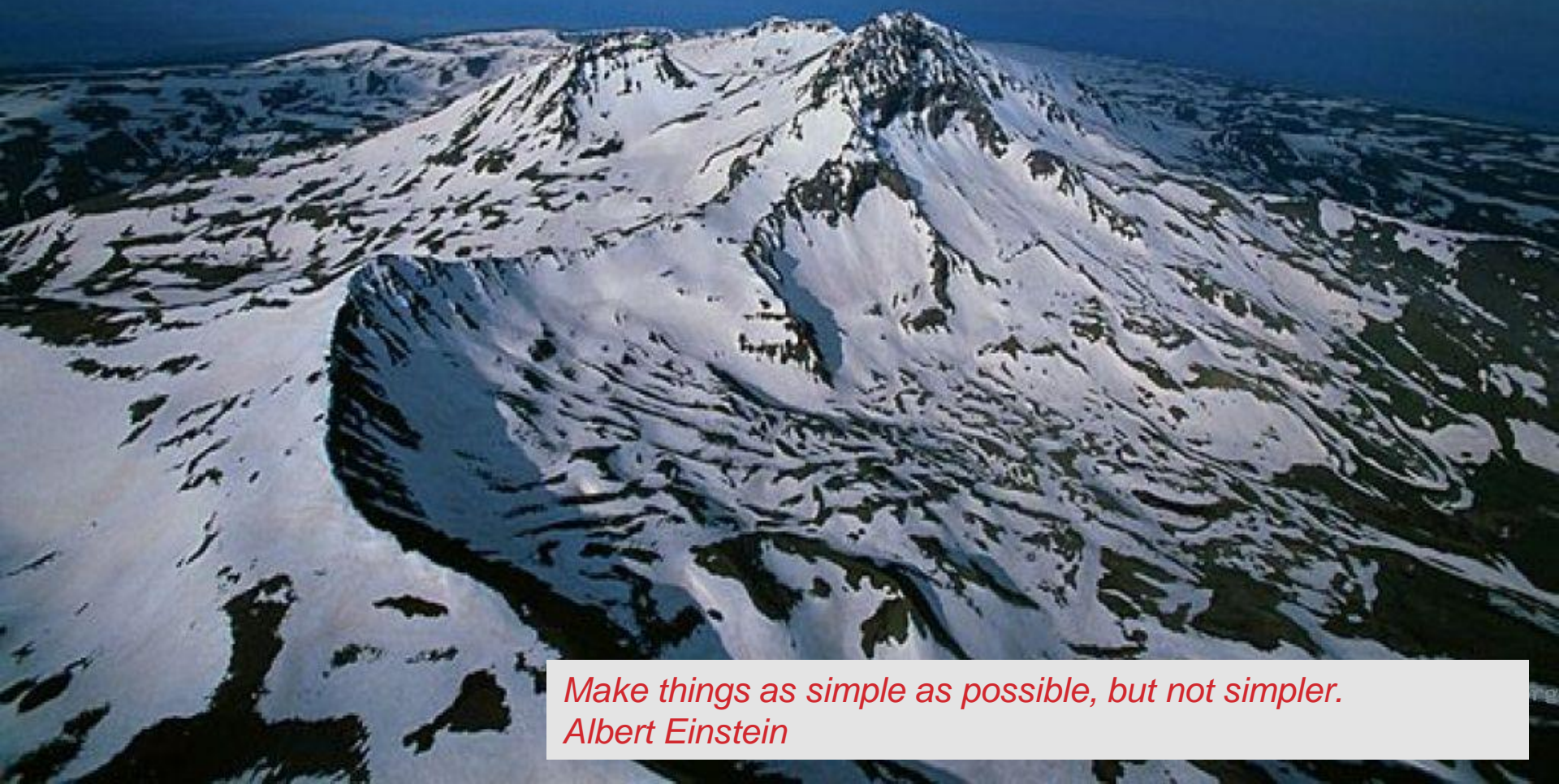


# ARAGATS STRATOVOLCANO IN ARMENIA – GEOLOGICAL HISTORY AND SPECIFIC ERUPTION PRODUCTS.

DR. KHACHATUR MELIKSETIAN,  
DEPUTY DIRECTOR FOR SCIENCE, HEAD OF LABORATORY OF VOLCANOLOGY,  
INSTITUTE OF GEOLOGICAL SCIENCES,  
ARMENIAN NATIONAL ACADEMY OF SCIENCES

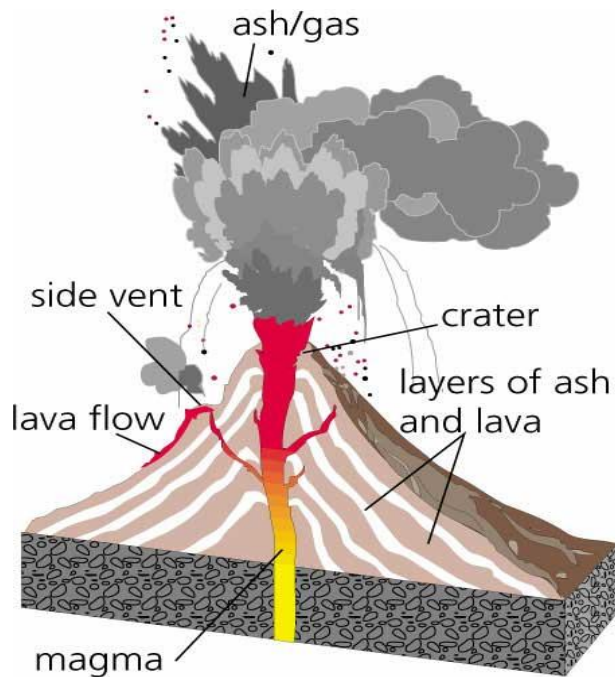


*Make things as simple as possible, but not simpler.  
Albert Einstein*

# WHAT IS VOLCANISM?

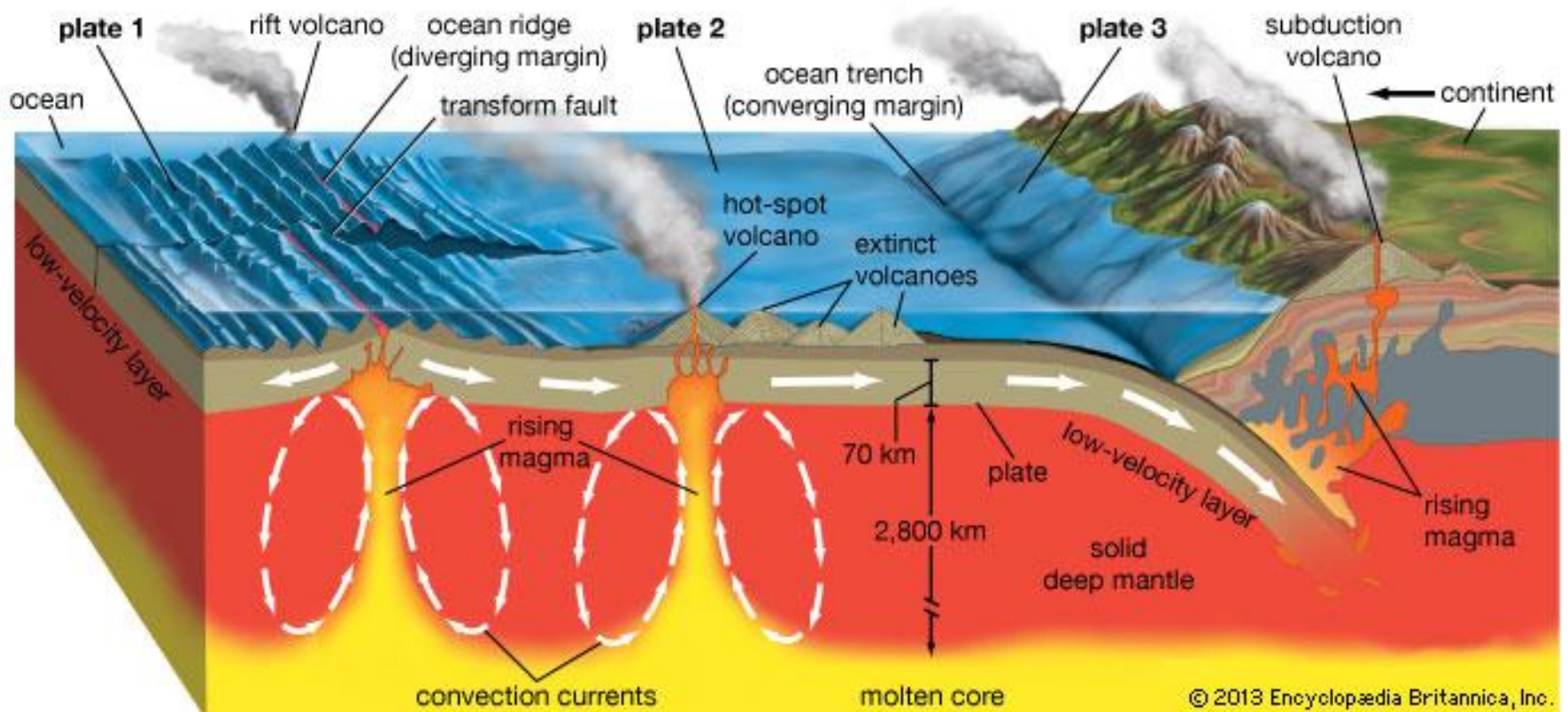
Generally speaking volcanism is eruption of molten rocks (lava) onto the Earth surface through a break in the surface called a vent (volcano or a fissure)

Volcanic phenomena are the surface manifestations of large scale geological processes that develop at significant depths within the Earth over prolonged periods of time.



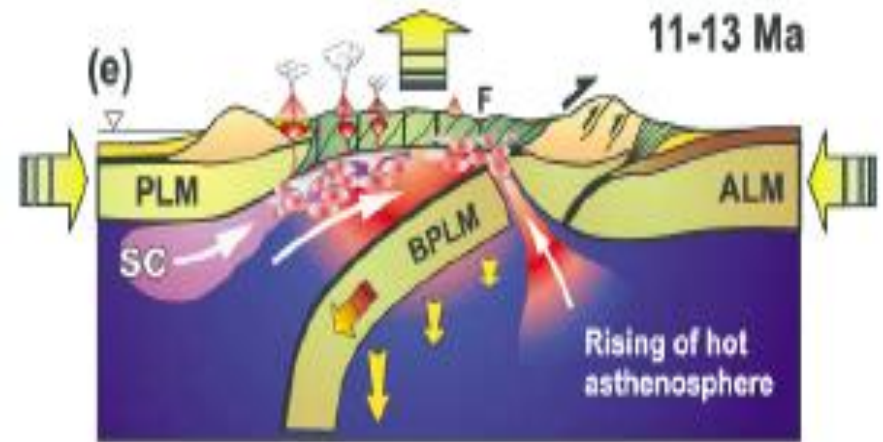
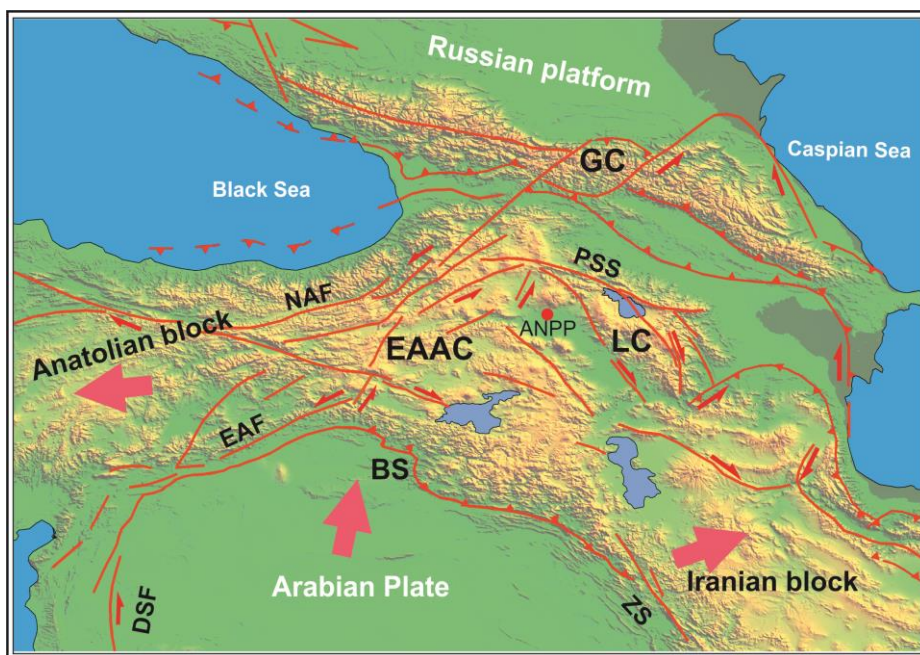
# WHAT CAUSES VOLCANISM?

Volcanism occurs at the boundaries of the Earth's tectonic plates which are a series of large blocks moving between each other, but also within tectonic plates (intraplate volcanism)



# WHAT CAUSES VOLCANISM IN OUR REGION?

Volcanism in Armenia, eastern Turkey, north west Iran and south Georgia is related to collision of Arabia with Eurasia occurred about 25 million years ago during geological period called Early Miocene. Arabian plate is still moving to the north, about 20 mm year<sup>-1</sup> and this stress causes volcanism and earthquakes in the entire region



# IS VOLCANISM DANGEROUS ?

Violent explosive eruptions are most dangerous ones, for instance

Mount Tambora eruption in Indonesia in 1815 killed 92,000 people. Volcano explosivity index (VEI), or magnitude of this eruption was 7, which is estimated to be equivalent of explosion of 800 megatons TNT)

Famous 79 AD eruption of Mount Vesuvius killed 18,000 people.

Violent explosive eruptions (VEI=6-10) may dramatically affect the climate due to effect of “volcanic” winter. Such an events are abundant in geological history of the Earth. Yellowstone caldera eruption (VEI=10) 650,000 years ago resulted Ice Age on the Earth that lasted until Holocene (11,700 years) when climate become warmer this period is also marked by important event in human prehistory - transition from hunting to early farming in the region of big Near East



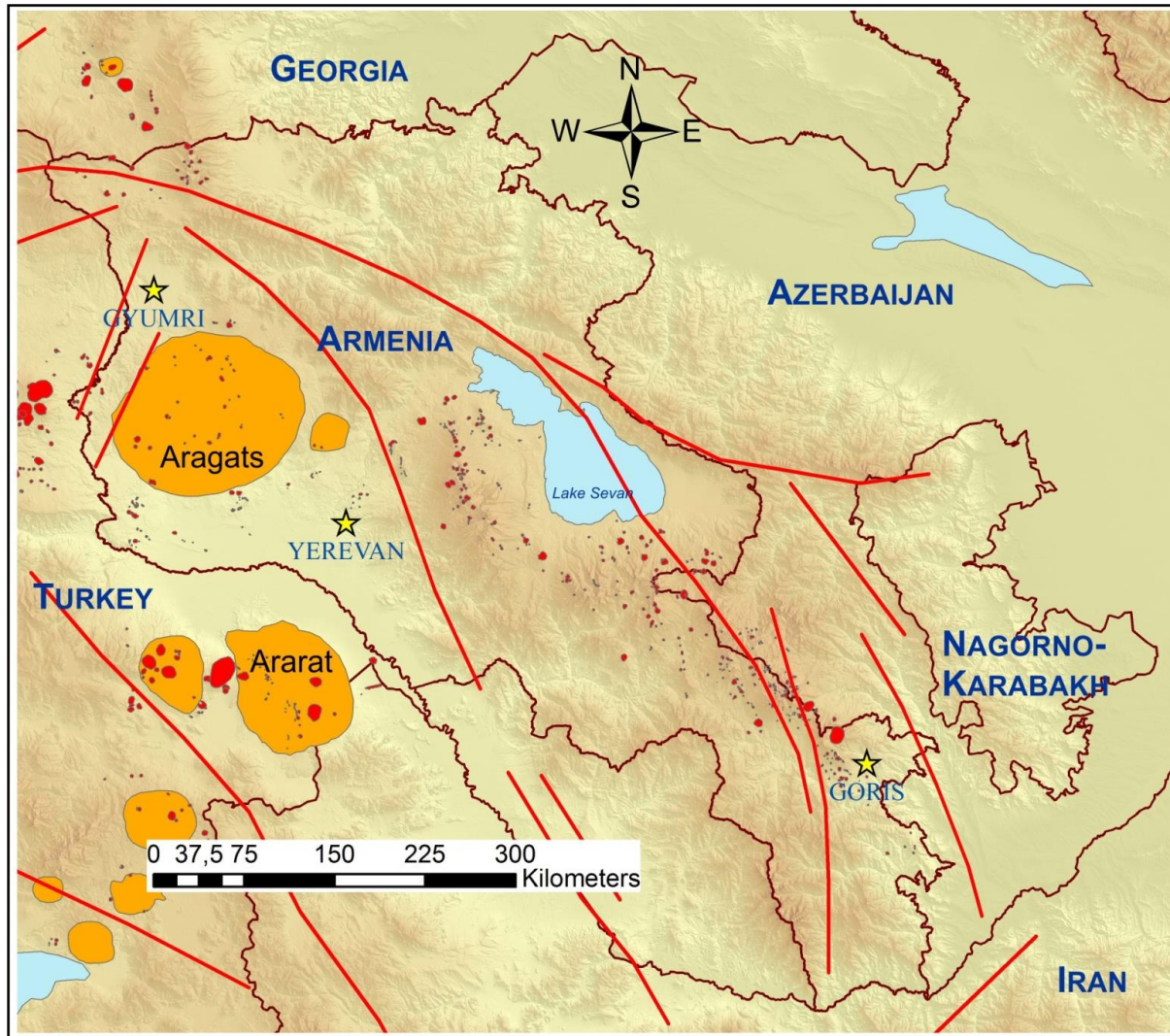
# A LINK BETWEEN VOLCANISM AND TEPA-2014 CONFERENCE ☺

Besides conference venue and research center located on Aragats volcano another link between TEPA-2014 and volcanism is phenomena known as volcanically induced lightning. Explosive eruptions usually cause dozens of strong lighting strikes in and around eruption column. This effect is one of the known atmospheric phenomena of volcanic eruptions.



# VOLCANISM IN ARMENIA

There are > 500 volcanic centers in Armenia, most of them are monogenetic cinder cones + 4 big stratovolcanoes- Aragats, Ararat, Tskhuk, Ishkhansar



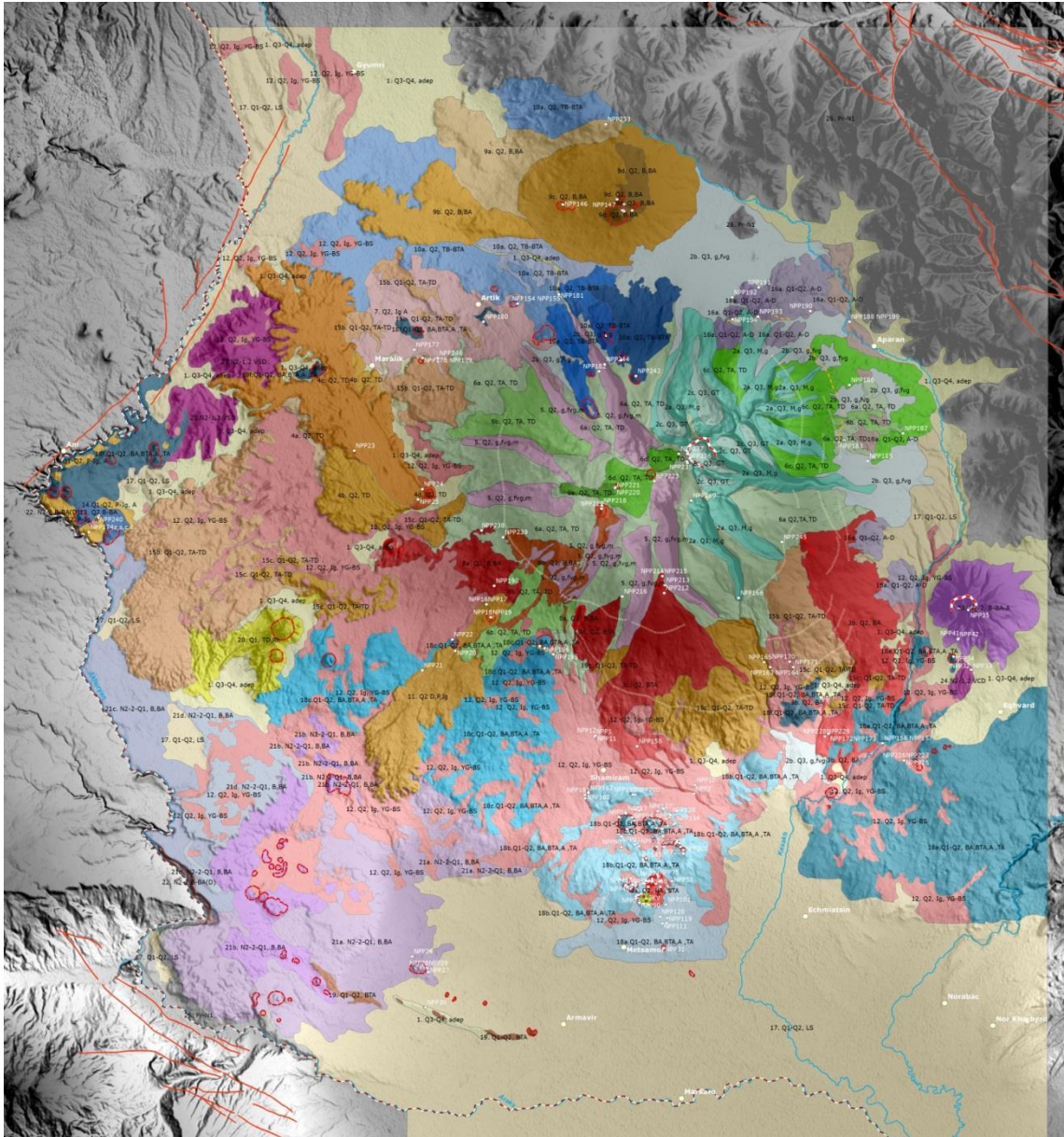
# **SPECIFIC FEATURES OF ARAGATS VOLCANO:**

- ❖ One of the largest volcanoes in the entire region
- ❖ Aragats and surrounding volcanic plateaus comprise Aragats volcanic province (AVP), covering an area of 5000 km<sup>2</sup>
- ❖ Period of activity of Aragats is more than 1 million years
- ❖ Last volcanic eruptions took place about 0.5 million years ago
- ❖ Aragats volcano produced several devastating explosive eruptions (VEI=5) during its activity period (tuffs or ignimbrites)
- ❖ Estimated total volume of erupted products is about 900 km<sup>3</sup>





# STRUCTURE OF ARAGATS VOLCANO



Aragats volcano appears as an oval shield

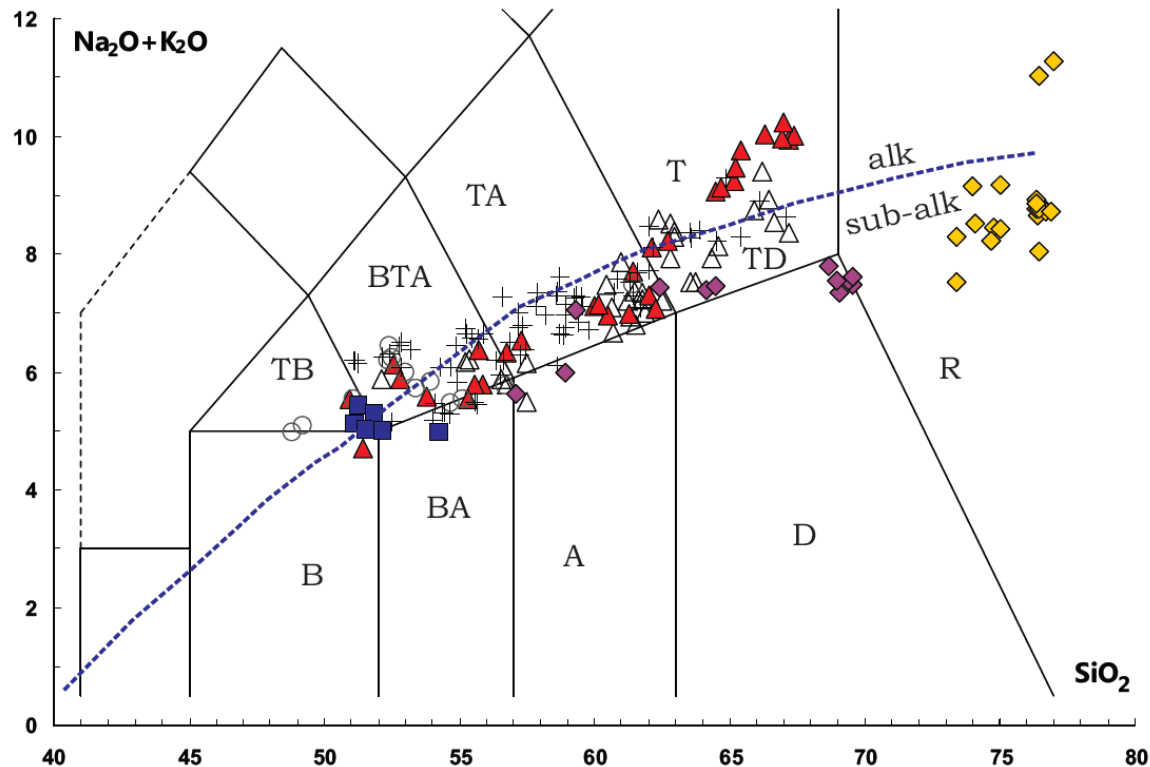
Crater of Aragats volcano is surrounded by 4 peaks, northern peak, the highest is 4090 high above the sea level

Glacial activity and related exaration play significant role in the modern landscape of the volcano. Volcano is cut by up to 400 m deep glacial valleys (now river gorges). Crater of volcano is also glaciated and appears as a glacial cirque.

Geological map of Aragats volcano

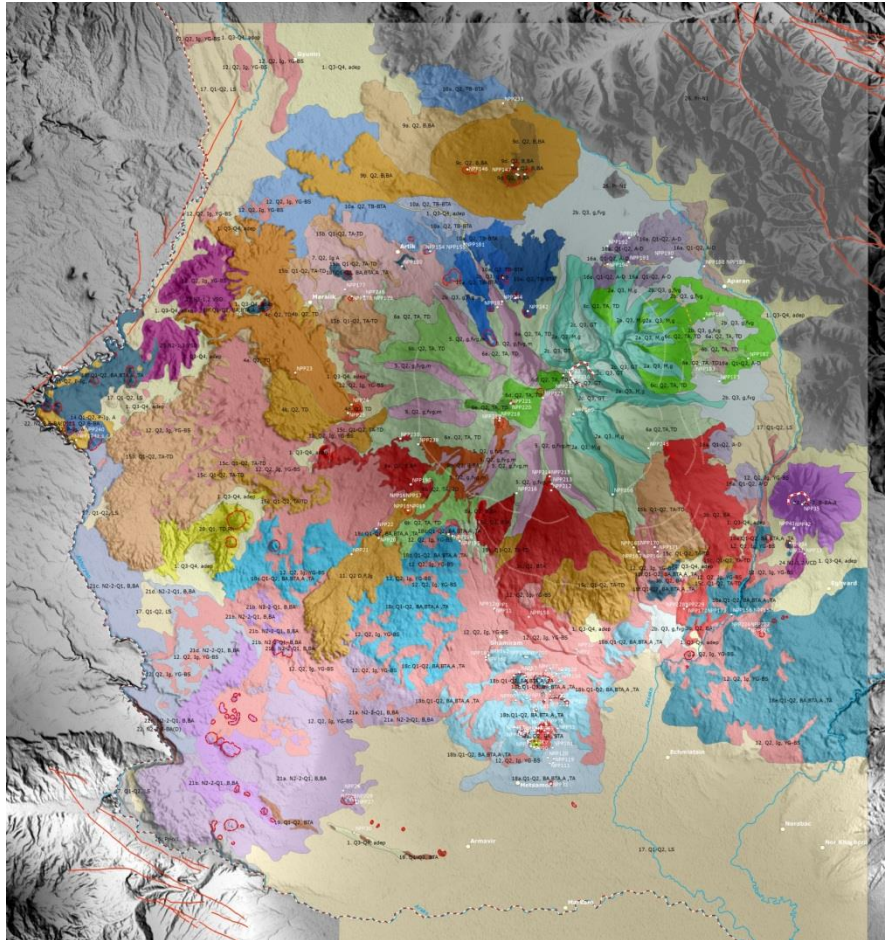
# ERUPTION PRODUCTS OF ARAGATS

Lavas erupted from Aragats volcano range in compositions from basaltic trachyandesites to trachydacites based on total alkalis vs. silica classification of volcanic rocks.



# CURRENT STUDIES OF ARAGATS VOLCANO

We focus on dating of volcanic eruption products, geological mapping, reconstruction of geologic history of volcano (volcano-stratigraphy)



Geological map of Aragats volcano

System	Stage	Geochronometry, Ma	Geological Unit	Age, Ma, K/Ar	Age, Ma, Ar/Ar	Stage	Description
Quaternary	0.0117		1. Q3-Q4, a,4,a,p			IV	Alkalis, silts, silts, proclasts deposits, pebbles, sand, sandy-silt, loam, rubble.
			2. Q1-Q16, N				Glacials and fluvio-glacial deposits, moraines
	0.126		3. Q2, B-SA	0.45-0.53	0.414	IV	Basaltic trachyandesites and basaltic-andesite lava flows, trachyandesite, trachyte
			4. Q2, TD		0.75		Trachyandesite lava flows of caldera-like volcano (Aragats)
	III		5. Q2, TA-TD			III	Glacials and fluvio-glacial deposits, of near the summit plateau
			6. Q2, TA-TD	0.73-0.54			Trachyandesites, trachyandesites, of near the summit plateau
			7. Q2, Ig, A				Tuffs (agglomerates) of Araks horizon
			8. Q2, B-SA				Basaltic and basaltic-andesite lava flows of Araksian, low slopes of Aragats
			9. Q2, B-SA				Basaltic and basaltic-andesite lava flows of Araksian (group of volcanoes (N. Aragats))
			10. Q2, TS-TBA	0.74-0.90			Trachyandesite and basaltic trachyandesite lava flows of Araksian plateau (A-A1)
			11. Q2, D,P,Ig		0.49		Flow of Araksian and Araksian plateau. Basaltic lava flows, Pleistocene eruption product basaltic deposits, trachyandesite ignimbrites.
			12. Q2, Ig, YG-B5		0.65-0.66		Ignimbrite tuffs of Araksian-group type and Araksian-Stratovirg subtype.
			13. Q1-2, B-SA				Basalts, basaltic-andesites, covering Araks type tuff
			14. Q1-2, P-Ig				Porphyro ignimbrite tuffs of Araks type
II	0.781		15. Q1-2, TA-TD, P			II	Trachyandesites, trachyandesites of slopes of Aragats, in South part covered by tuffic debris.
			16. Q1-2, A-D				Flow of Araksian plateau deposits of Pleistocene.
			17. Q1-2, A-D				Basaltic, basaltic, basaltic and trachyandesites of Araksian and Araksian plateau, trachyandesite, trachyte and other older stages.
			18-Q1-2, TBA-TA	0.91-1.10	0.71-1.32 0.809		Upper unit of lake sediments deposits of Araks and Araksian plateau, trachyandesite, trachyte, basaltic and trachyandesites of Araksian and Araksian plateau, trachyandesite, trachyte and other older stages.
I	1.806		19. Q1-2, A-D	0.92-0.99	0.902	I	Basaltic trachyandesites of Araksian structure
			20. Q1, TD-Rh	1.45-1.60			Trachyandesites and rhyolites of Araks volcano
			21. N1-Q1, B-SA				Basaltic and basaltic-andesite of N and low Aragats
			22. N1, B-SA (D)	2.20-2.50			Basaltic basaltic and basaltic andesites
			N1, BA, A, Ig				Upper (lower) lava and ignimbrite (outcropped in canyon)
			23. N1, B-SA-A				Basaltic series of Araks polygenetic volcano
			24. N1, VCD				Volcanoclastic deposits (trachyandesite tuff-?)
Neogene	3.60		25. N1, VSD			I	Volcano-sedimentary deposits, Araks-Bakurashan suite.
			5.332				

Stratigraphy of Aragats volcano

# AGE OF ERUPTIONS OF ARAGATS DETERMINED BY K-Ar AND $^{40}\text{Ar}/^{39}\text{Ar}$ ISOTOPE DATING METHODS

- ❖ The earliest volcanism related to Aragats stratovolcano itself is dated to  $1,543,000 \pm 24,000$  years
- ❖ Youngest volcanic activity for central edifice of Aragats is  $520,000 \pm 10,000$  years
- ❖ Youngest volcanic activity from side vents (Tirinkatar, Irind, Ashtarak) is dated to  $450,000 \pm 23,000$  years,  $490,000 \pm 11,000$  and  $582,000 \pm 15,000$  respectively.



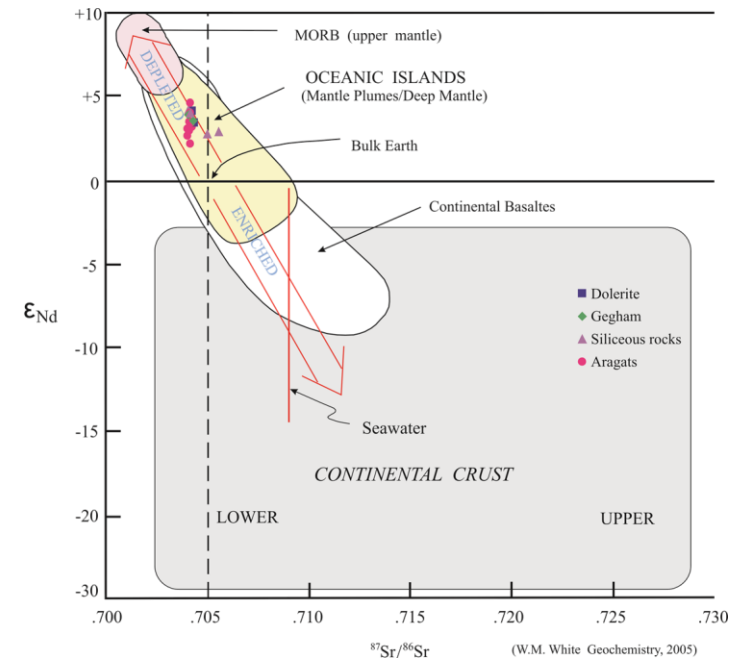
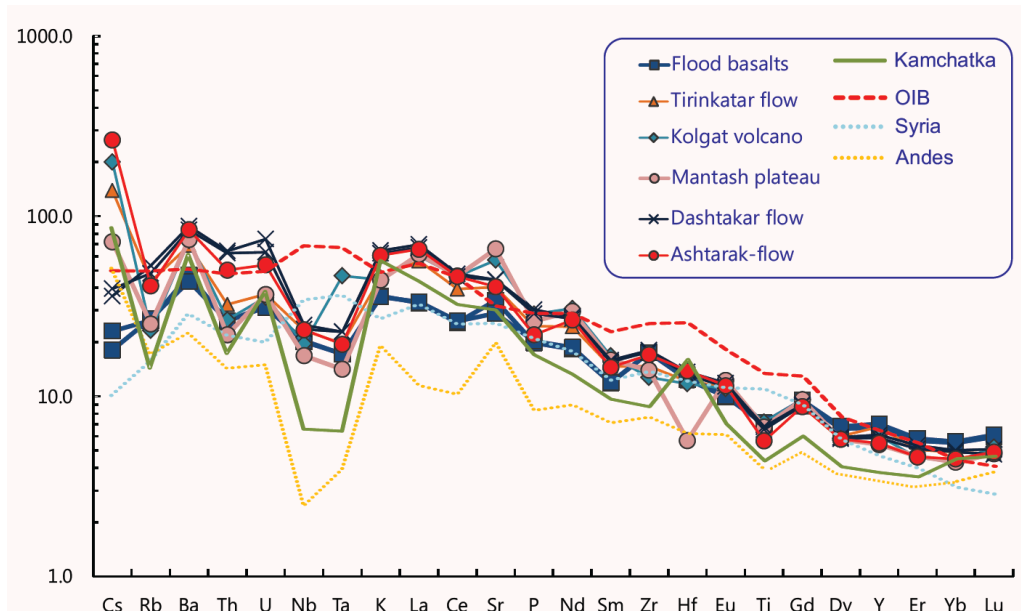
Plinian fall deposit at Irind volcano, south slopes of Aragats.



Southern and western summits of Aragats and dacite dome near the lake

# STUDY OF GEOCHEMICAL FEATURES TO RECONSTRUCT ORIGIN AND SPECIFIC FEATURES OF MAGMA GENERATION AND DEPTHS BENEATH ARAGATS

## Major and trace element geochemistry and radiogenic isotope geochemistry



## **IS THERE VOLCANIC HAZARD IN ARMENIA?**

**Yes there is, since volcanic systems that were active during last upper Quaternary (last 120,000 years) are considered to be potentially active, while systems active in Holocene (last 11,700 years) are considered to be active. But Aragats is considered to be extinct volcano, since last activity is dated to 0.5 million years.**



**Nazeli volcano, Syunik volcanic upland, 7,350 years old, dated by He<sup>3</sup> cosmogenic isotope dating method.**

**Some monogenetic cinder cones in Armenia were active in Holocene (<11700 years) and erupted during last 3-7 thousand years. Tondrak, Nemrut and Ararat in eastern Turkey were active in historical time.**



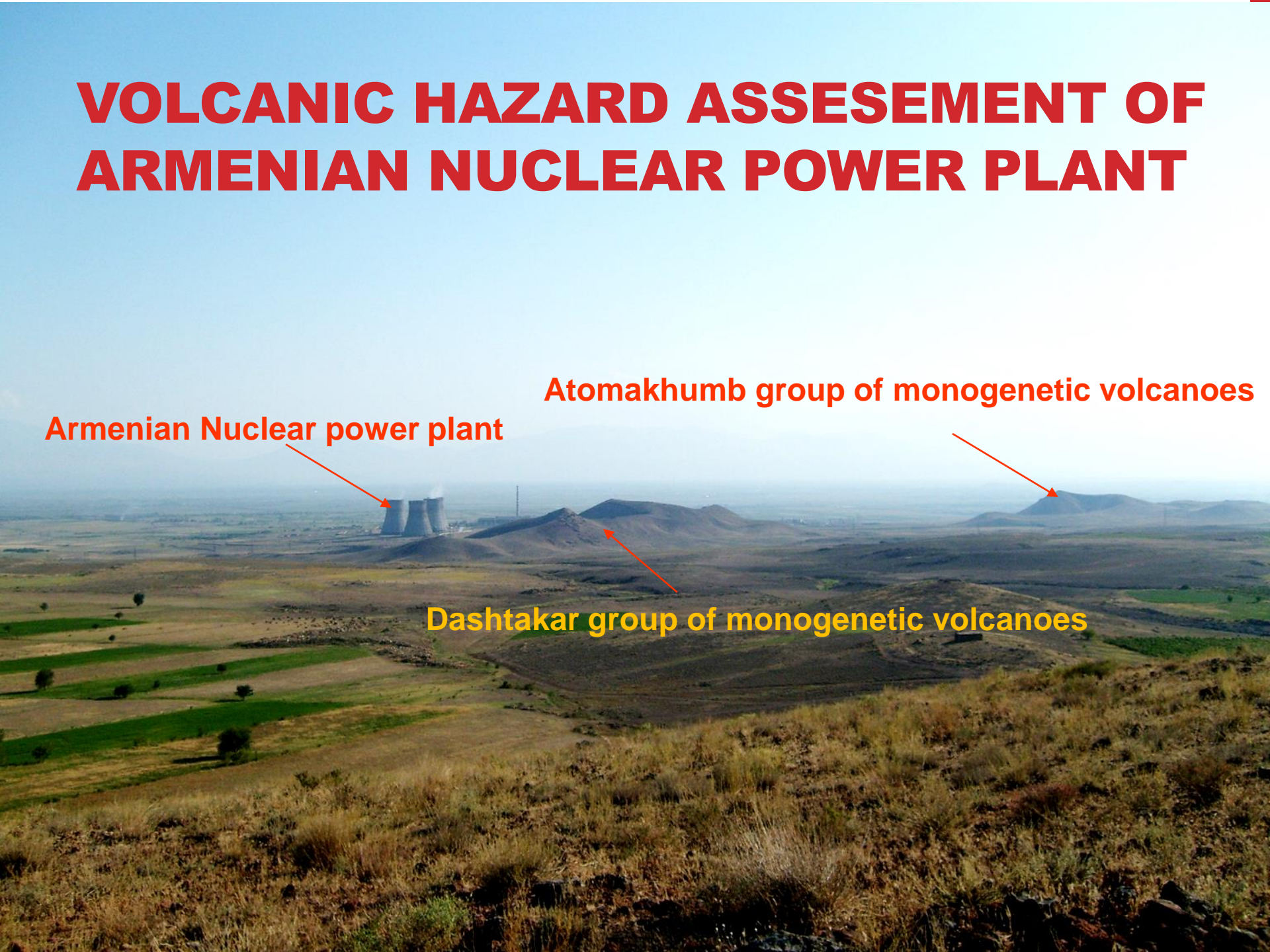
**Red triangles show locations of Holocene volcanoes in Armenia, as well as Ararat with flank activity in Holocene and phreatic eruption in 1840.**

# **VOLCANIC HAZARD ASSESEMENT OF ARMENIAN NUCLEAR POWER PLANT**

**Armenian Nuclear power plant**

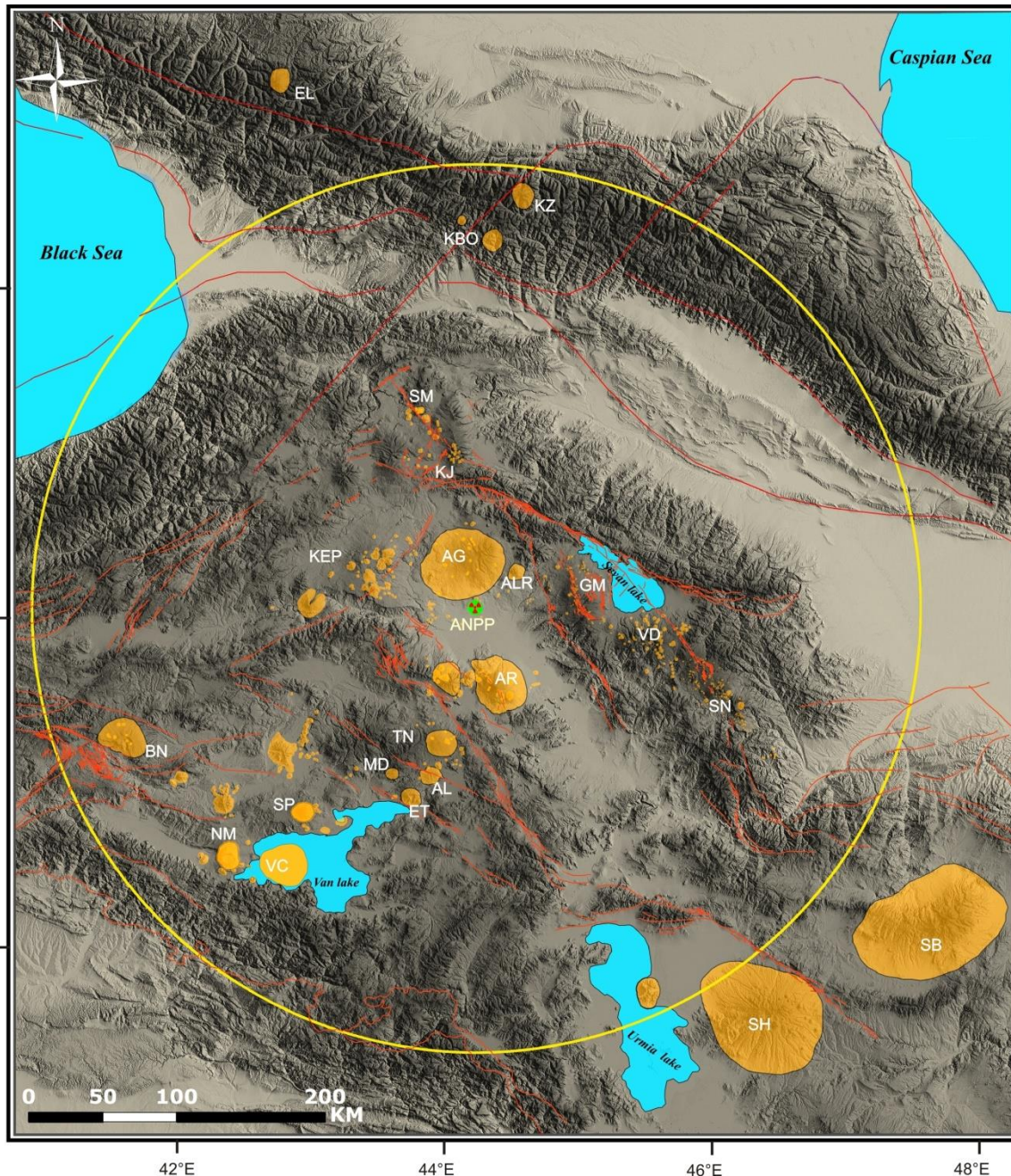
**Atomakhumb group of monogenetic volcanoes**

**Dashtakar group of monogenetic volcanoes**





# Distribution of volcanoes in 300 km zone around ANPP



The Armenian Nuclear Power Plant (ANPP) is located in a region of Quaternary (<1.8 Ma) and Holocene-Historical (<11.7 Ka) volcanism.

Because of this fact, volcanic hazards potentially exist for facilities at the ANPP site, and these hazards must be evaluated in a quantitative way according to IAEA safety guide SSG-21

IAEA Safety Standards

for protecting people and the environment

Volcanic Hazards in  
Site Evaluation for  
Nuclear Installations

Specific Safety Guide

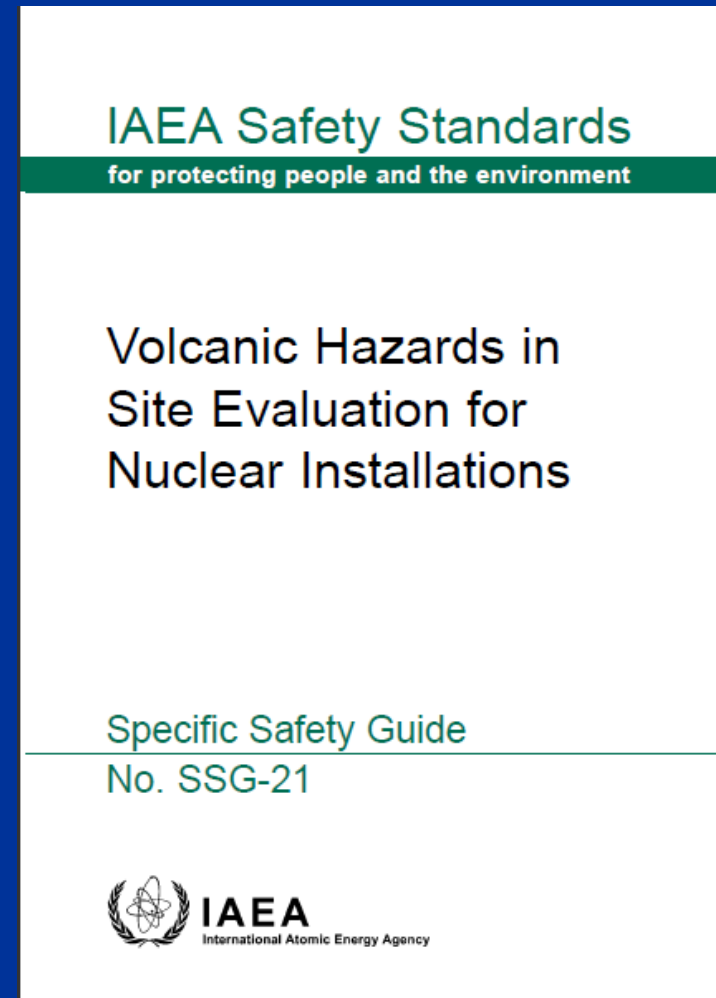
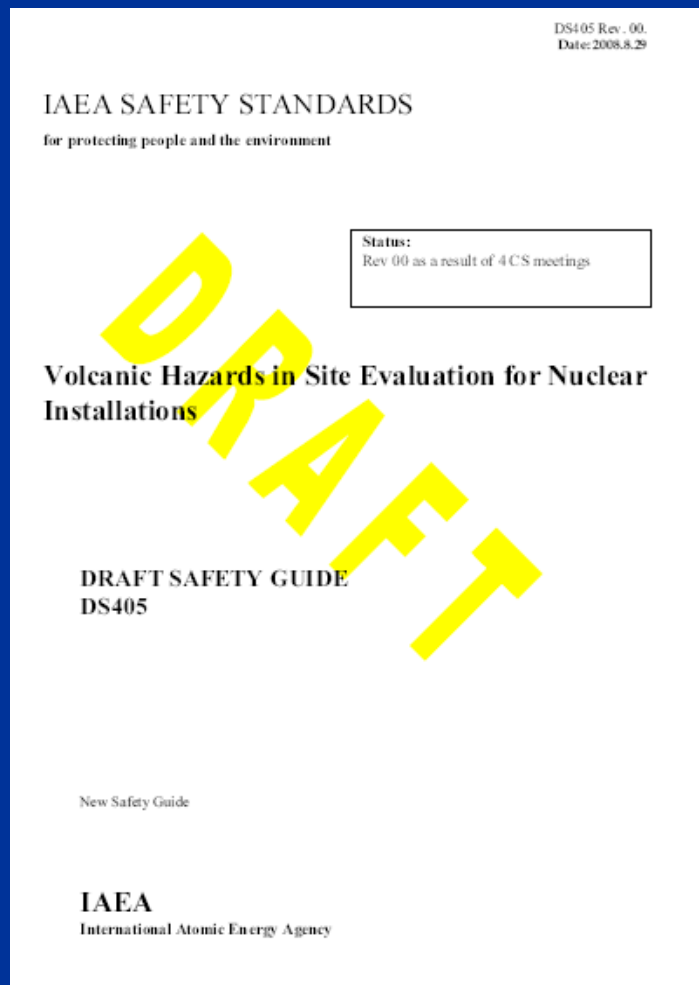
No. SSG-21

# “NorAtom” Consortium

- **International consortium was founded in 2009 to assess seismic and volcanic hazards for new nuclear power station site in Armenia (near existing station)**
- **Consortium Members:**
- **Georisk CJSCo, Armenia**
- **Institute of Geological sciences, Armenia (IGS ANAS)**
- **University of South Florida, USA**
- **University of Leeds, UK**
- **Expert council members – leading seismologists and volcanologists from USA, France, Italy.**

# Volcanic hazard assessment

- **Armenian nuclear power station is first one, for which volcanic hazards evaluated according to IAEA DS-405 draft safety guide (2011 revision), now accepted as SSG-21 IAEA Safety Guide**

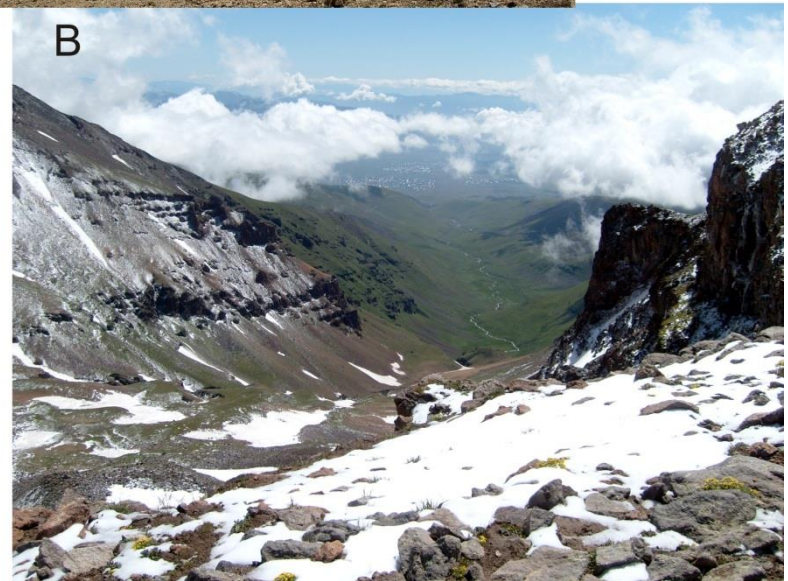


# Reviews of volcanic hazard assessment of ANPP by IAEA missions in 2010 and 2011

IAEA review missions recognized volcanic hazard assessment of Armenian nuclear power plant as an example work and invited our team members to develop official IAEA guidelines and technical documentation for volcanic hazard assessment of nuclear installations. This work will be published by the end of this year.



# THANK YOU FOR YOUR ATTENTION



Crater of Aragats volcano