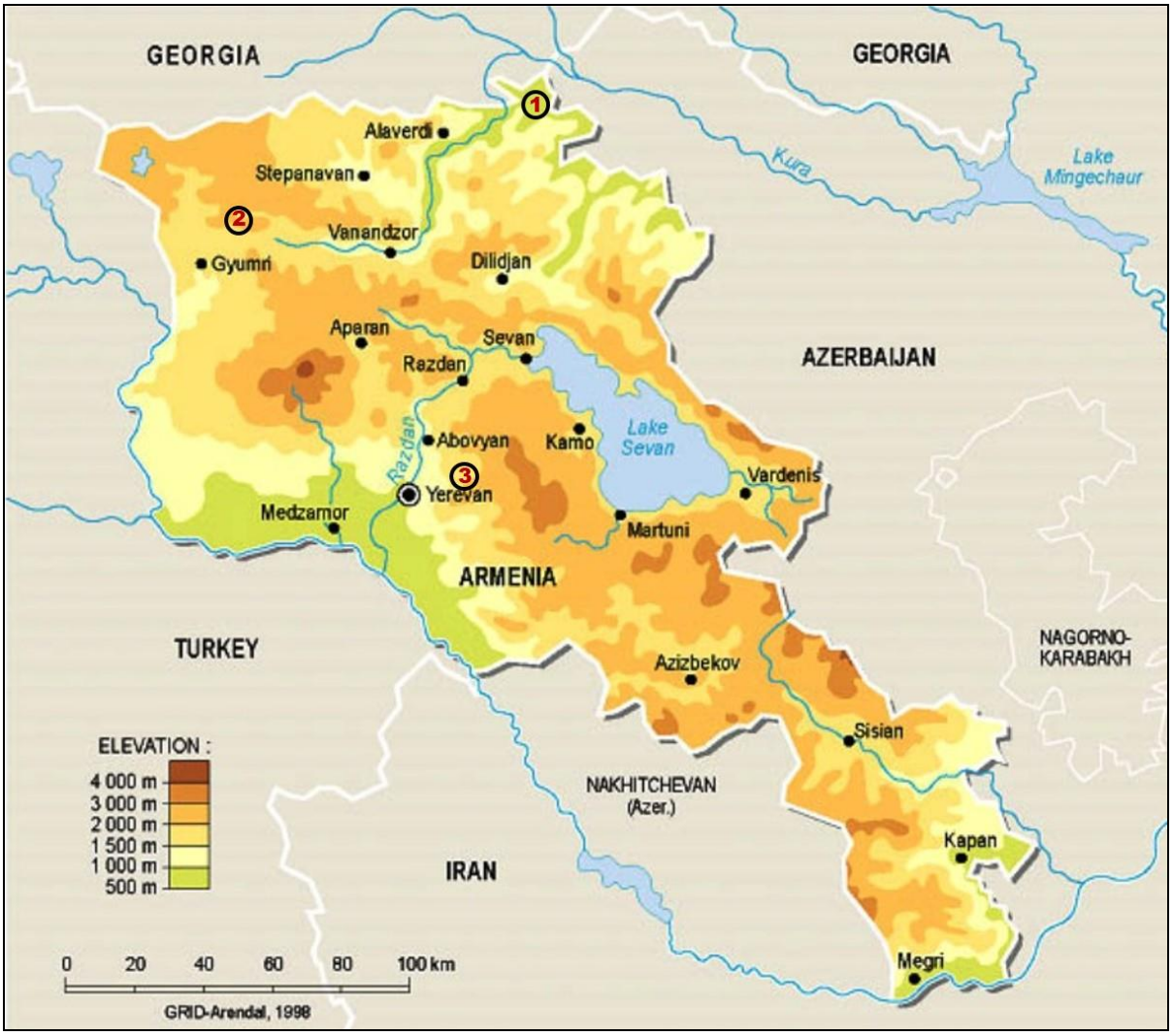
Sedimentary Zeolite Deposits in Armenia



Exploited deposits: During the last 30 years several geological formations were explored as potential sources of sedimentary zeolites in the Republic of Armenia. Consistent amounts of zeolitic rocks were found in tuffaceous rocks spread over different areas. At present three groups of deposits are exploited (see map)

No.	DEPOSIT	PROVINCE	AREA
1	Noyemberyan	Tavush	Far NE Armenia
2	Shirak	Marz	NW Armenia
3	Garni-Gokht	Kotayk	Central Armenia

Among these the most promising is the Noyemberyan group of deposits and the following discussion provides more details about the Noyemberyan group.

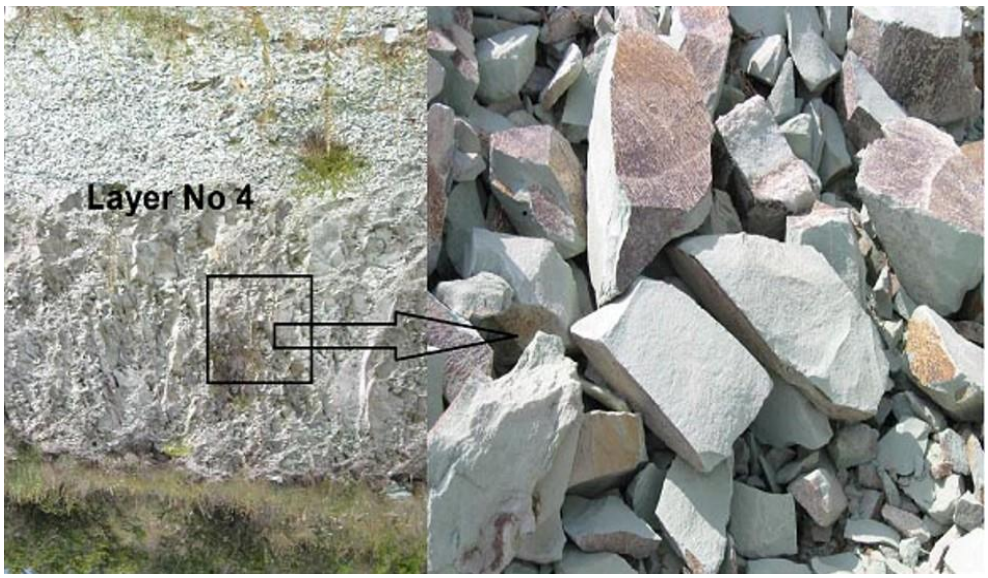
Zeolite occurrence: Mostly clinoptilolite-rich tuff

Geology: The Noyemberyan group of zeolite and bentonite deposits is located within the belt of outer ranges of the minor Caucasus, in the extreme north-eastern area of the Republic of Armenia, approximately 15 km northwest from the city

of Noyemberyan, and 7-8 km south of Berdavan village. The area of this deposit group is about 30 km^2.
The Noyemeberian group of deposits belongs to Upper Santonian - Lower Campanian (Mid to Late Cretaceous) formations, with a thickness up to 600 m. They are composed of zeolite- and smectite-altered ash-flow tuffs and ignimbrites, tuffaceous sandstones, limestones, marlstones, and volcanic glass. Morphologically the zeolite- and smectite-altered rocks are in bedded and rarely lenticular bodies. The beds usually dip southeast at 10 to 25˚. Zeolite beds are traced for up to 3 km along strike and up to 2 km down dip. Their thickness in outcrops is usually varies from 5 to 15 m, in some places reaching 150 m. The most promising deposits are as follows:

Name	Thickness and mineral composition
New	Five layers of zeolitized rocks (analcime and mordenite). Two upper layers 34 m thick contain clinoptilolite
Nor Kokhb	Four interbedded layers of zeolites, containing about 80% clinoptilolite, the thickness of which ranges from 1 to 100 m
Central	Zeolite-bentonite rocks, containing mainly clinoptilolite, the thickness of which ranges from 30 to 150 m
Southern	Zeolite tuff layers; the upper one contains clinoptilolite, mordenite and smectite
North-West	Mainly felsite tuffs

Zeolite-bearing rocks are constituted of pyroclastic materials of dacitic, rhyodacitic and rarely trachyandesitic composition. The initial pyroclastic sediments are related to explosive activity of island arc paleovolcanoes and are classified into two basic genetic types: ash flow tuffs ash fall tuffs (2). Zeolitic rocks from Nor Kokhb deposit possess the best characteristics for exploitation, mainly because of their clinoptilolite content.



Nor Kochb location, clinoptilolite-rich rock fragments (photo by Sh. Khachatryan)

Mineralogy:

Zeolite rocks are variable both in their mineral and chemical composition. According to Table 1, some are essentially mono-zeolitic, e.g. (a) clinoptilolite-rich (60 to 85% clinoptilolite), (b) stilbite-rich (60 to 80% stilbite), (c) analcime-rich (35 to 60% analcime), but zeolite assemblages (bearing both mixed zeolites and smectites) are the most common occurrences. Accompanying phases are quartz, albite, illite, barite, and volcanic glass (1-6).

Table 1. Mineral composition of "mono-zeolitic" rocks[1]

Mineral	CLI	STI	ANA
Clinoptilolite	60-85	4-10	-
Stilbite	2-4	60-80	-
Analcime	-	2-3	35-60
Mordenite	2-10	-	2-5
Smectite	10-20	4-8	10-18
Plagioclase	5-10	5-10	3-8
Cristobalite[2]	5-15	5-12	3-11
Quartz	1-5	2-4	1-7
Magnetite[3]	≤5	2-3	1-5
Biotite	0-1	2-3	1-2
Pyroxenes & amphiboles	1-5	1-3	2-6
Volcanic glass	5-20	8-25	5-32

[1]Nor Kokhb deposit; CLI = clinoptilolite-rich; STI = Stilbite-rich; ANA = Analcime-rich;
[2] Including chalcedony and opal;
[3] Including ilmenite and iron hydroxides.

Chemistry:

The composition (major element oxides) of representative tuffs of the Noyemberyan group of deposit (Nor Kokhb deposit) is shown in the following Table 2.

Table 2. Representative chemical compositions of zeolitic tuffs

Oxides	CLI[1]	STI[1]	ANA[1]	Mixed[2]
SiO_2	69.40	68.10	67.57	74.37
TiO_2	0.19	0.32	0.39	0.09
Al_2O_3	13.10	14.00	16.06	10.94
Fe_2O_3	0.80	1.57	2.58	0.81
MnO	-	0.02	0.02	-
MgO	1.00	1.32	2.09	1.52
CaO	2.05	2.40	2.15	1.62
Na_2O	0.85	1.30	2.00	0.33
K_2O	1.80	3.20	2.30	1.35
P_2O_5	-	-	-	-
H_2O (LOI)	11.51	8.46	5.34	9.25
Total	100.70	100.69	100.50	100.28
Si/Al	4.51	4.13	3.56	5.83

[1]CLI = clinoptilolite-rich; STI = Stilbite-rich; ANA = Analcime-rich.
[2] Silica-rich tuff sample containing a mixture of two or more zeolites.

The cation exchange capacity of representative clinoptilolite-rich samples from Nor Kokhb averages 136 meq/100 g.

Physical and mechanical properties:

Some physical properties of the clinoptilolite-rich materials from Nor Kokhb deposit (1-6) are summarized in the following box:

Specific surface area (m^2/g)	12.0-18.0
Density (g/cm^3)	2.40-2.65
Bulk density powder (g/cm^3)	1.7-1.95
Open porosity (%)	37.7-56.7
Compressive strength (MPa)	35-45
Thermal stability (°C)	300-400

Reserves and production: Potential resources of zeolites in Armenia are estimated at up 500 megatonnes. The whole annual production capacity is roughly 100,000 tonnes, mainly for export.

Main applications: At present, the domestic use of Armenian zeolites is limited to agriculture as soil amendments and to husbandry as a food additive for chickens and other animals. Zeolite grains are also sporadically used as filtering materials in aquariums.

References

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