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Geoecological assessment of the environment: An example from the territory of Georgia

Murman Kvinikadze, David Kuparadze, Thomas Kerestedjian, Iraklii Sirbiladze

Abstract. The study represents the results of an extended study of the main geoecological components of the environment. The study combines direct investigations and an exhausting review of the existing geological information. The results are represented as a set of maps with their respective explanatory notes as follows: map of the natural hydrogeological conditions of Georgia; map of the natural hydrogeochemical conditions of Georgia; map of the natural geological (seismic) conditions of Georgia; map of the natural hydrometeorological conditions of Georgia; map of the human-induced geochemical conditions of Georgia; map of the human-induced hydrogeochemical conditions of Georgia; map of the natural geoecological conditions of Georgia with main environment polluting sources.

Key words: Environmental state, geoenvironmental hazards, geochemistry, hydrogeology, seismic, hydrometeorology

Addresses: M. Kvinikadze, D. Kuparadze and I. Sirbiladze – Caucasian Institute of Mineral Resources, 85 Paliashvili str., 0162 Tbilisi, Georgia; E-mail: kuparadze@mail.ru; T. Kerestedjian – Geological Institute, Bulgarian Academy of Sciences, 1113 Sofia, Bulgaria

Мурман Квиникадзе, Давид Купарадзе, Томас Керестеджиян, Ираклий Сирбиладзе. Геоекологична оценка на състоянието на околната среда: Един пример от територията на Грузия

Резюме. Представени са резултатите от обширно изследване на основните геоеколожки компоненти на околната среда. Данните съчетават преки изследвания и изчерпателен обзор на съществуваща геоложка информация. Резултатите са представени в набор от карти със съответните обяснителни бележки към тях, както следва: карта на природните хидрогеоложки условия на Грузия; карта на природните хидрогеохимични условия на Грузия; карта на природните геоложки (сеизмични) условия на Грузия; карта на природните хидрометеороложки условия на Грузия; карта на техногенните изменения на геохимичните условия на Грузия; карта на техногенните изменения на хидрогеохимичните условия на Грузия; карта на естественото геоеколожко състояние на Грузия с основните обекти – замърсители на околната среда.

Introduction

Together with the positive effects of the industrial development, the disrespectful human impact on the environment has always been representing a serious hazard, both for the nature and the mankind. Considering the ecological pressure, Georgia makes no exception.

Current paper represents the results of two recent research projects implemented by the Caucasian Institute of Mineral Resources (CIMR): a) an international project on the "Geology, geodynamics, minerogenesis and current geoecological conditions of transgressive sedimentary basins and folded structures in Central Eurasia" targeted on the creation of maps in 1:2 500 000 scale; b) an independent project of the geoecological department of CIMR, targeted on the creation of a geoecological map of Georgia in 1:500 000 scale.

All the results are represented in a set of maps (1:2 500 000 scale), with their respective explanatory notes, following the mapping methodology and symbolic sets provided by the Kazakh YUGGEO institute – the coordinating party of the first project.

Current geoecological factors

Current geoecological situation of the country is mainly determined by the ecological pressure of the following factors:

1. Geochemical, hydrogeochemical and bio-geochemical pollution, caused by: Chiatura, Kvaisa, Tkvarcheli, Tkibuli and Madneuli mining industrial complexes; Rustavi and Zestafoni smelting plants; Batumi oil refinery; Supsa petrol loading terminal; Uravi and Djugareshi arsenic enterprises; oil and gas pipelines Baku-Djeihan and Baku-Erzerum.
2. The radiation background, caused by: a) natural U-Ra-Th-K nuclides and b) human induced radioactive pollution, recorded after the Chernobil NPP burst.

Maps

Natural hydrogeological conditions

The map on Fig. 1 represents data on fresh ground water reserves. They belong to 3 ecological types: I. ecologically protected; II. ecologically unprotected and III. ecologically poorly protected. Ecologically protected category comprises mainly the waters of the Caucasian ridge. These waters are mostly connected to primary rocks, with drain modules 10-35 l/sec per km^2. The ecologically unprotected waters are mainly represented in the Quaternary sediments of the Kolkheti lowland and Kura-Alazani valley with drain modules of 2-5 l/sec per km^2. The ecologically poorly protected waters, with drain modules of 5-10 l/sec per km^2 are represented in basic and carbonate rocks, lava formations of the South slopes of Great Caucasus and Javakheti uplands.

Anomalous concentrations of chemical elements and compounds of ecological concern are represented with boundaries and numeric code explained therein.

Natural hydrogeochemical conditions

This map (Fig. 2) is based on the 1:500000 scale landscape-climatic divisions map of Georgia (Davitaia, 1970). The numeric markings of the landscape-climatic units have the following meaning:

1. high mountain humid area of snow-drifts and glaciers (Western part of Great Caucasus)
2. high mountain semi-humid area of snow-drifts and glaciers (Eastern part of Great Caucasus)
3. upland steppes (Meskhet-Javakheti upland).

1-3 – high mountain zone (above 2500 m)

4. humid climate with cold winter and long summer (Western territories)
5. semi humid climate with cold winter and long hot summer (Eastern territories). 4-5 – foothill zone (1500-2500 m)

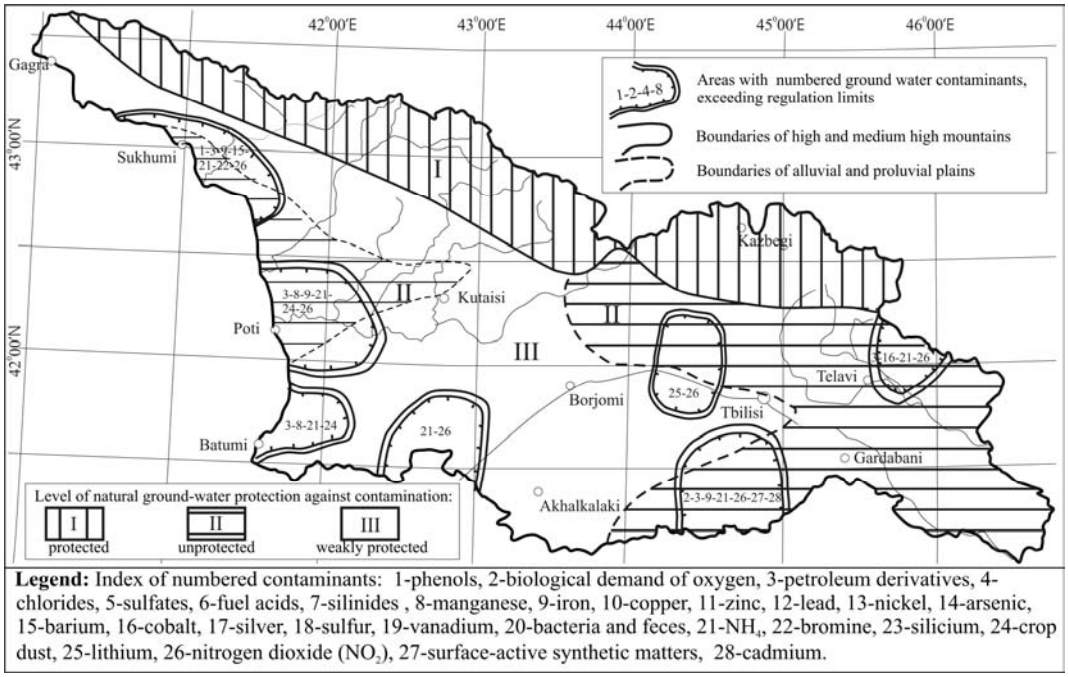

Fig. 1. Natural hydrogeological conditions

Фиг. 1. Естествени хидрогеоложки условия

6. semi humid climate (Eastern Georgia, Alazani valley)
7. moderate worm steppes with hot summer (Yor plateau). 6-7 – upland zone (500-1500 m)
8. maritime, semi humid subtropical climate (sheer coastline of the Black Sea)
9. humid – semi humid subtropical climate (the rest of the lowlands – up to Imereti uplands). 8-9 – Kolkheti hinterland lowlands (below 500 m)

The hydrogeochemical character and abundance of the main mineral water sources of the country is given in Table 1. Temperature and age of the hosting rocks are also given for the thermal sources (Table 2).

Other hydrogeochemical features to stress on this scale: a) natural radioactive anomalies. They are connected to granite bodies or coal placers and are never too big. All of these spots have been outlined at the end of 20th century and need due monitoring; b) gushes of methane and helium have been registered on the shelf zone, close to the town of Poti. Their source is unknown at the time being; c) according to the level of pollution (pollution index) 3 zones are outlined in the Black Sea aquatic area of the country.

Natural seismological and geo-engineering conditions

This map (Fig. 3) represents both surface (exogenous) and underground (endogenous) ongoing processes, concerning the geo-ecological characterization of the area.

Most common and dangerous processes on the steep slopes of Great and Small Caucasus (on Georgian territory) are landslides, mud floods and erosion. On the South slopes of

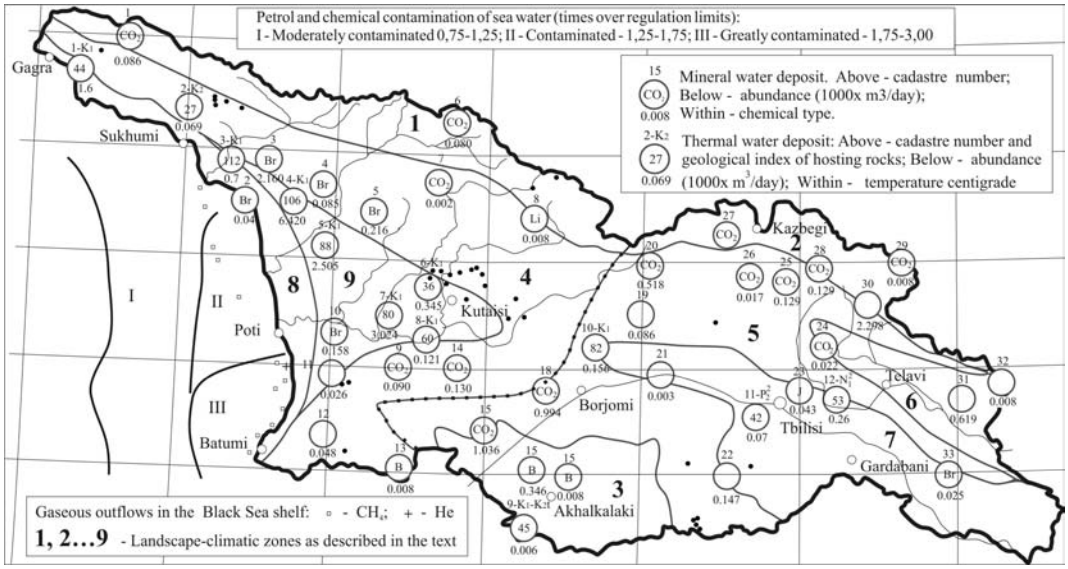

Fig. 2. Natural hydrogeochemical conditions

Фиг. 2. Естествени хидрохимични условия

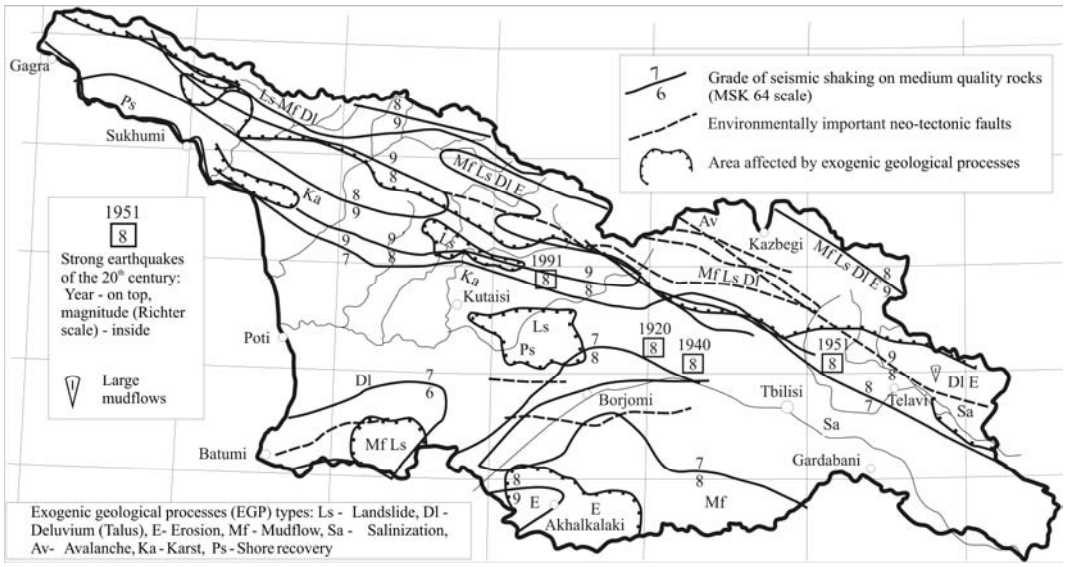

Fig. 3. Natural seismic and geo-engineering conditions

Фиг. 3. Естествени сеизмологични и инженерно-геоложки условия

Table 1. *Geochemical type of the mineral water sources*

Таблица 1. *Геохимичен тип на минералните извори*

№	Name	Type	Abundance: thousands m^3/day
1	Avadkhara	CO_2	0.086
2	Otchamtchire	Br	0.004
3	Mokvi	Br	2.160
4	Okumi	Br	0.008
5	Lugela	Br	0.216
6	Mestia	CO_2	0.080
7	Lentekhi	CO_2	0.002
8	Utsera	Li	0.008
9	Nabeglavi	CO_2	0.090
10	Djimiti	Br	0.158
11	Ozurgeti	-	0.026
12	Kokotauri	-	0.048
13	Khikhadziri	B	0.008
14	Sairme	CO_2	0.130
15	Akhaltsikhe	CO_2	1.036
16	Nakalakevi	B	0.346
17	Akhalkalaki	B	0.008
18	Borjomi	CO_2	0.994
19	Khenti	-	0.086
20	Java	CO_2	0.518
21	Gorisdjvari	-	0.003
22	Bolnisi	-	0.147
23	Norio	J	0.043
24	Gombori	CO_2	0.022
25	Vazhas-Tskaro	CO_2	0.129
26	Pasanauri	CO_2	0.017
27	Arsha	CO_2	0.216
28	Salile-Goris-Vedza	CO_2	0.129
29	Omalos-Vedza	CO_2	0.008
30	Torgvas-Abano	-	2.298
31	Oktomberi	-	0.619
32	Lagodekhi	-	0.008
33	Mlashekhevi	Br	0.025

Great Caucasus rock falls and karst in Cretaceous carbonate rocks are common too.

Along the Black sea coastline the most dangerous process is coast demolition, often caused by human activity. An example of such demolition is the sea advance towards the Bichvinta resort, caused by the stopped supply of river sediments by the Bzifi river.

Among the endogenous processes, the most important from the geoecological point of view is the seismic activity of neo-tectonic faults. The Georgian territory and the Caucasus as a whole is an active seismic zone (Gamkrelidze et al., 1998). Disastrous earth-quakes with magnitudes 8-9 (Richter's scale) caused significant losses in human lives and wealth several times during the last century. As seen on the map, Southern and Eastern part of the country was mostly active during that period.

Hydrometeorological conditions

This map (Fig. 4) is based on data from the Georgian Hydrometeorological survey. It represents some geoecologically important features, like wind directions and frequency, yearly precipitation amounts etc. As it can be seen, regardless of the small territory of Georgia, its amplitude of yearly precipitations is pretty large: from 2400-4000 in Batumi region (Black Sea coast) to less than 400 in the Gardabani area (Eastern Georgia).

Another important characteristic from geo-ecological point of view is the natural surface water resources. Their distribution in economic watershed management units and their drainage parameters are given in Table 3. The overall mean yearly drainage is 65 720 km^3/year, falling down to 47 680 km^3/year in dry years. Some hydrological characteristics for the main Georgian rivers are given in Table 4.

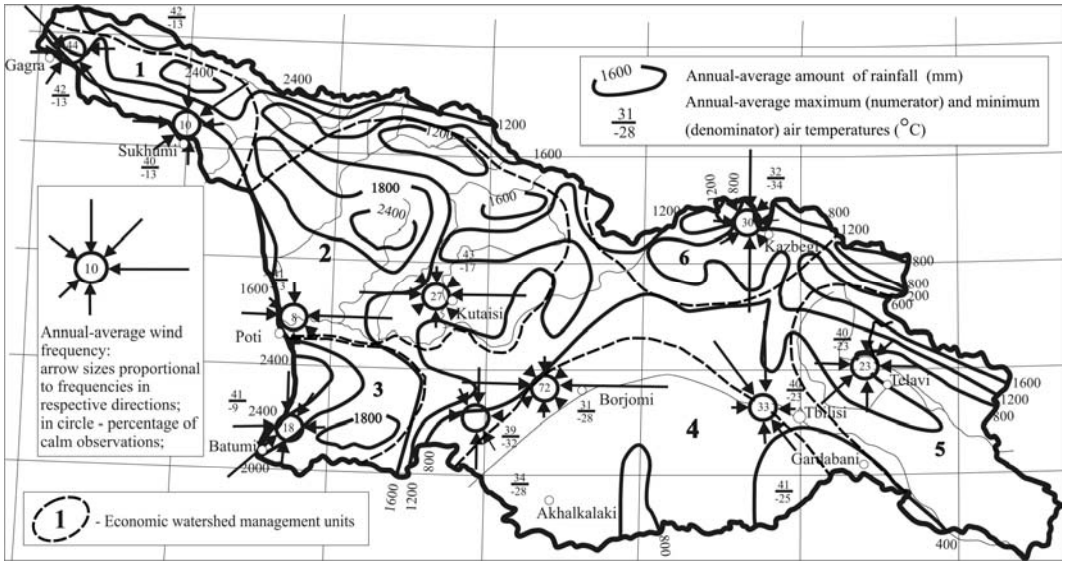

Fig. 4. Hydrometeorological conditions

Фиг. 4. Хидрометеорологични условия

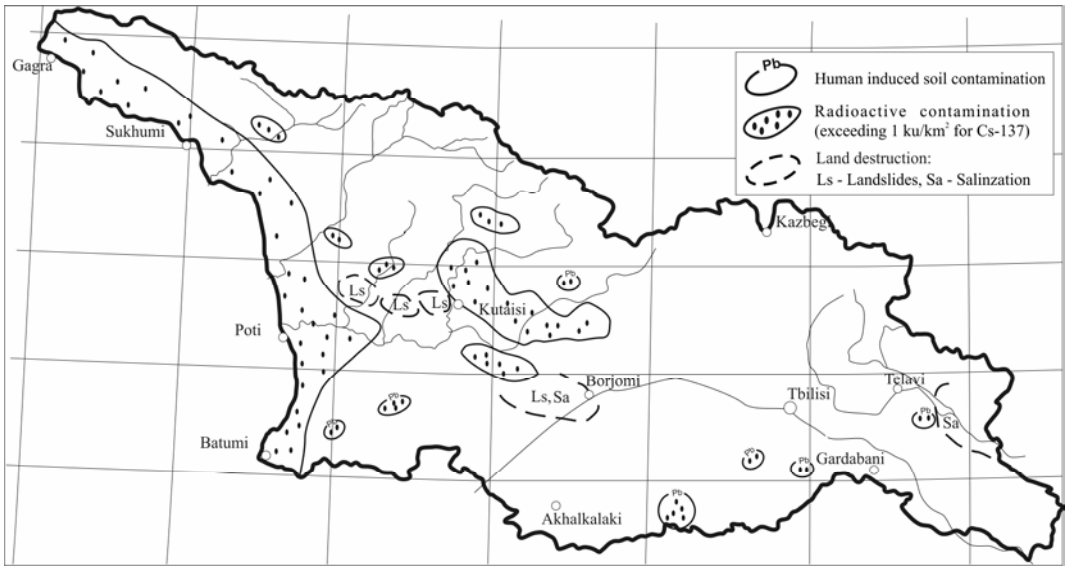

Fig. 5. Human induced changes in geoecological conditions

Фиг. 5. Антропогенни изменения на геоеколожките условия

Table 2. *Characteristics of the thermal water sources*
Таблица 2. *Характеристики на термалните извори*

№	Name	Type	Temperature, ^{0}C	Age of the hosting rocks	Abundance: thousands m^3/day
1.	Gagra	H_2S	44	K_1	1.6
2.	Sukhumi	H_2S	27	K_2	0.069
3.	Kindgi	SiO_2	112	K_1	0.7
4.	Okhurey	SiO_2	106	K_1	6.420
5.	Zugdidi	SiO_2	88	K_1	2.505
6.	Tskaltubo	Ra	36	K_1	0.345
7.	Samtredia		80	K_1	3.024
8.	Vani	B	60	K_1	0.121
9.	Vardzia	B	45	K_1-K_2t	0.006
10.	Agara	SiO_2	82	N	0.156
11.	Tbilisi	H_2S	42	P_2^2	0.007
12.	Udjarma		53	N_1^2	0.26

Human induced changes in geoecological conditions

Haloes of soil contamination with heavy metals and radioactive substances are shown of Fig. 5.

Heavy metal contaminations are the result of both agricultural and industrial activities during the Soviet period, implemented without any environmental concern. All these contaminations currently need due revision.

Radioactive pollution of soils has first been recorded in Georgia after the Chernobil NPP burst. Records many times exceeding the regulation limits have been collected in Western Georgia and especially along the Black Sea coast (Information Bulletin, 2000). The represented map reflects the data collected up to year 1995.

Geo-engineering human induced conditions (both human caused and human activated) are shown on the map too. Most of them are landslides.

Human induced changes in hydrogeological conditions

Human induced pollution of surface and underground waters both with heavy metals and organics (oil and oil derivatives) is shown on fig. 6. As seen, there are some highly polluted areas in the Southern part of the country. This is especially true for the Madneuli gold-base-metal deposit, where the situation can be described as disastrous. The concentrations of heavy metals in the local Mashavera river and its tributaries Kazretula and David-Garedji are as follows: Cu – 222-710 mg/l (maximum allowed concentration MAC - 1 mg/l); Zn – 13-578 (MAC - 1); Mn – 2-175 (MAC - 0.1); Pb – 5.7 (MAC - 0.03); Cd – 33.6 (MAC – 0.01). Similar situation can be observed also in the Uravi ore concentration plant, where arsenic ores are processed.

Combined influence of natural and human induced geoecological factors

This is the map where all of the above data are consolidated to produce a practical guide of overall ecological conditions (Fig. 7).

The regions on the territory of the country have been categorised according to their habitability. Four categories have been derived:

1. with most unfavourable conditions – deserts, high mountains;

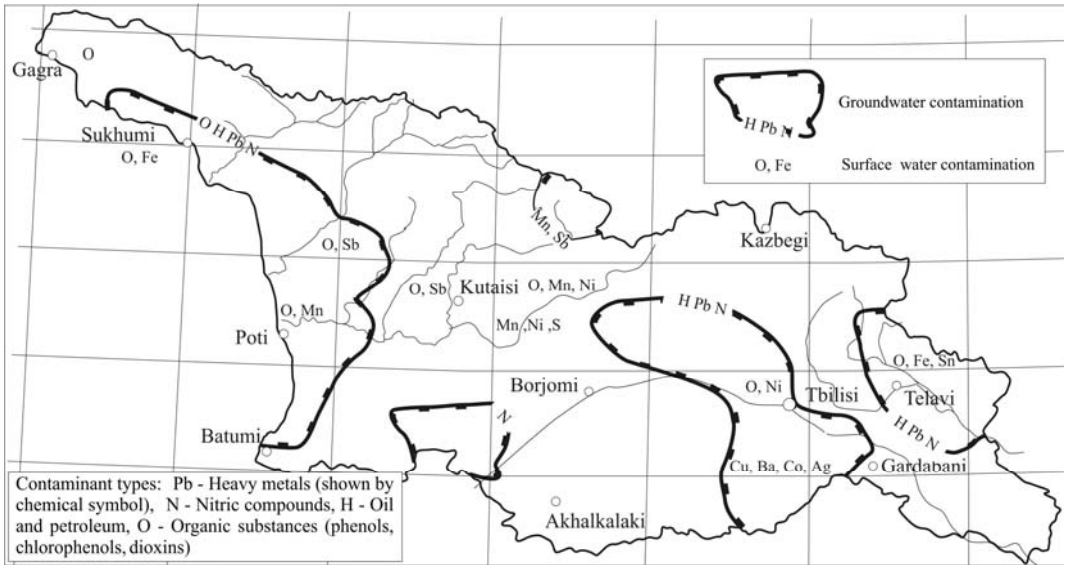

Fig. 6. Human induced changes in hydrogeological conditions

Фиг. 6. Антропогенни изменения на хидрогеоложките условия

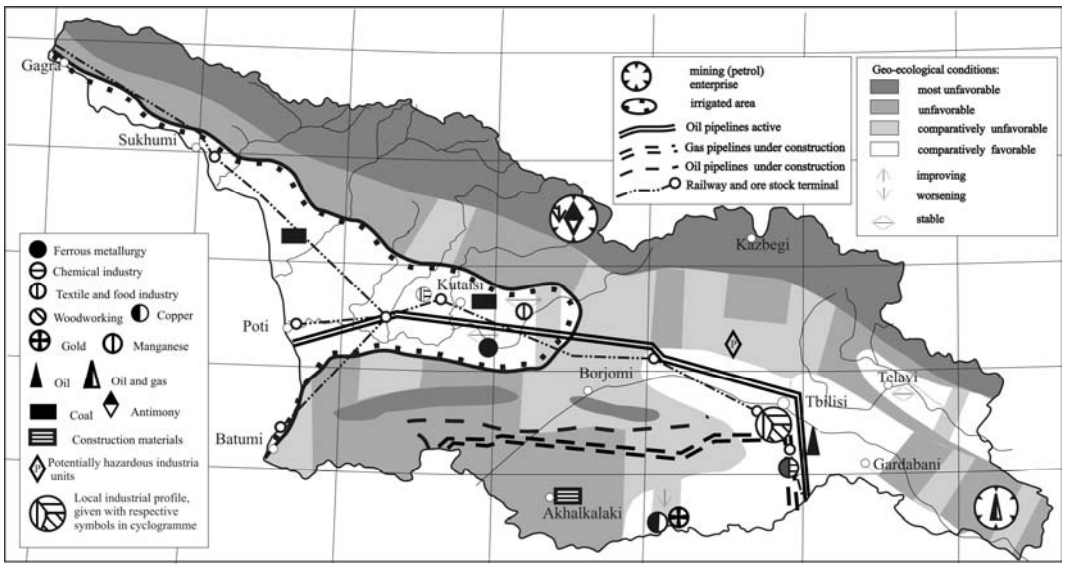

Fig. 7. Combined influence of natural and human induced geoecological factors

Фиг. 7. Обобщено въздействие на естествените и антропогенни геоеколожки фактори

Table 3. *Distribution and characteristics of surface water reserves in economic watershed management units*
Таблица 3. *Разпределение и характеристики на повърхностните водни резерви по басейнови управленски единици*

№	Watershed management unit	Mean yearly flow km^3/year	Drainage in dry years (95% of confidence)
1.	Psou – wright coast of Enguri (Psou, Bzifi, Gumista, Kelasuri, Kodori)	14.736	10.757
2.	Enguri – Rioni (Enguri, Khobi, Rioni with tributaries)	17.225	12.574
3.	Supsa – Turkish boundary (Supsa, Natanebi, Kintrishi, Adjaritskali, Chorokhi)	220.689	15.562
4.	Mtkvari (Mtkvari, Liakhvi, Ksani, Aragvi, Khrami)	8.069	5.648
5.	Yori – Alazani (Yori, Ilto, Alazani, Stori,Durudji)	2.757	1.645
6.	Northern slopes of Caucasian Ridge (Tergi, Arguni, Tusheti Alazani)	2.064	1.404
	Overall	65.720	47.680
	Including transited	8.322	

Table 4. *Hydrological parameters of main rivers*
Таблица 4. *Хидроложки параметри на основните реки*

Name	Monitoring point	River length (km)		Watershed, thousands of km^2		Mean yearly debit m^3/s	Drainage km^3/year
		overall	in Georgia	overall	in Georgia		
Kodori	Varcha	84	84	2.03	2.03	135	4.260
Enguri	Chuberi	213	213	4.06	4.06	142	4.481
Rioni	Poti	327	327	13.4	13.4	404	12.749
Chohokhi	Erge	438	438	22.0	0.26	278	8.773
Mtkvari	Tbilisi	1364	381	188.0	23.056	204	6.438

2. with unfavourable conditions – deserts, mountains, flatlands without rivers and ground waters;
3. with comparatively unfavourable conditions – regions with water deficit;
4. with comparatively favourable conditions – regions with enough water reserves, flatlands, lowlands.

The most important sources of geoecological danger are shown here too. Along with these, the trends in changing geoecological conditions are shown with special symbols. As it is seen, the most polluted areas are those of Madneuli and Uravi industrial enterprises, where the geoecological trends are extremely negative.

Stabilization of the geoecological conditions is observed at Chiaturi mining enterprise and Zestafoni ferro-alloy factory. The main reason for this trend seems to be the decreasing mining and processing of the Mn ores.

Especially should be emphasized the stabilization and improvement of the geo-ecological situation on arable lands in Alazani valley. The substitution of chemical fertilisers with natural manure is the main reason of both

diminishing the metal and organic pollution and increasing of land fertility.

Conclusions

In geoecological respect almost the whole territory of Georgia is stable, excluding few isolated spots. The overall pollution index is comparatively low. Mapped geoecological anomalies are of local significance only. Considering the water resources, which are one of the most important wealth items of the Georgian economy, the regulation limits (MAC) for most elements should be brought in agreement with European standards. This will improve the level of their protection.

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