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GRUZBURGEOTHERMIA

ASSESSMENT OF OPERATIONAL RESERVES OF THERMAL WATER IN ZUGDIDI-TSAISHI DEPOSIT (For Reference Only)

GEORGIA

October 24, 1984 -(date is preparation date/submitted March 1997)

Prepared by: Tbilisi Research Institute of Geothermy "Gruzburgeothermia" (Translated by Burns & Roe -Tbilisi)

Submitted to: U.S. Agency for International Development

Contract No.: CCN-0002-Q-00-3154-00
Energy Efficiency and Market Reform Project
Delivery Order No. 25,
Subtask I: Assessment of Zugdidi Geothermal District Heating System

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Burns and Roe Enterprises, Inc.
1400 K Street N.W., Suite 1050. Washington, DC 20005
(202) 408-6831 Fax (202) 408-6835

March 18, 1997

Mr. Iqbal M. Chaudhry
U. S. Agency for International Development
320 21st Street N.W., Rm 4440 NS
Washington, DC 20523

Subject: Contract CCN-0002-Q-00-3154-00
Delivery Order No. 25 - Georgia
Zugdidi Geothermal District Heating System
EBRD Reconstruction Proposal - Preliminary Draft Report

Dear Mr. Chaudhry:

The Government of the Republic of Georgia has requested that the EBRD assist in preparing a district heating project for Zugdidi to utilize geothermal energy. USAID has agreed to fund a preloan project assessment and provide the services of Burns and Roe Enterprises to undertake the tasks specified in Delivery Order No. 25.

Attached is a copy of the preliminary report on the Zugdidi Geothermal Assessment prepared in Tbilisi by ARCI Consulting under the direction of Burns and Roe Enterprises, Inc. This report covers about 60% of the ARCI work required for preparation of the EBRD Pre-Loan Assessment.

The work remaining for completion of the Delivery Order includes, but is not limited to, the following:

1. Limited testing of the resource/wells (May 1997)

2. Privatization and Ownership Proposal

   a. Development of a program of institutional reforms for the Government of Georgia to privatize the geothermal production and district heating systems by means of a joint stock company.
   b. Recommendations on a company ownership structure, legal framework and management requirements for implementing and operating the Zugdidi geothermal production and district heating distribution system, maintenance practices, staffing and training needs, etc.
   c. Description of the legal requirements and framework for company relationships with local authorities, the Government of Georgia, international business and the EBRD.

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3. Preparation of tender documents if project is approved by EBRD.

4. Preparation of Final Report.

Also attached is a translation from Russian of a report titled "Assessment of Operational Reserves (Capacity) of Thermal Water in Zugdidi-Tsaishi Deposit (Republic of Georgia)" published October, 1984. This report provides a great deal of history on the development of the resource, the geology and geochemistry up to that time.

We have also included about thirty pages of miscellaneous documents previously prepared over the past year which we hope you will find of interest to point out the importance of the success of the Zugdidi project to Georgia. Some of this information has been provided to Ambassador Courtney.

Zugdidi is about 2 Km from the border to Abkazia and the Inguri hydro power plant and is of political importance for maintaining stability in the region. Zugdidi is economically important because of the large number of commercial enterprises located in the region. These enterprises are key elements in implementing the institutional reforms necessary for privatization and developing a strong free market economy. Already there is strong interest by German companies in forming joint ventures with these enterprises.

The success of these reforms, encouraging foreign investment and redevelopment of the infrastructure, will strengthen the ability of the local government to provide the cash flow necessary to repay the EBRD loan.

If you have any questions, please call me at (202) 408-6831, x14.

Prepared by:
John E. Hallberg, P.E.
Task Manager

Sincerely,

Douglas D. Tuckhorn
Project Director-Caucasus

Attachments
c: P. Feeney, USAID, (T)
J. Hallberg, BREI (NJ) (w/o attach)
L. Hultin, EBRD (UK)
Z. Menteshashvili, BR (T)
W. Smith, USAID (Y)
G. Weynand, USAID (DC)
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ASSESSMENT

OF

OPERATIONAL RESERVES

OF

THERMAL WATER

IN

ZUGDIDI-TSAISHI DEPOSIT

REPUBLIC OF GEORGIA

OCTOBER 24, 1984

(Translated from Russian)

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Name of the document (report): Assessment of operational reserves (capacity) of thermal water in Zugdidi - Tsaishi deposit (Republic of Georgia).

Subject (Work): Assessment of operational resources (capacity) of thermal water in Zugdidi - Tsaishi deposit (Republic of Georgia).

Organisation - performer of work: Tbilisi Research Institute of Geothermy of the department "Gruzburgeothermia":
Address: 380077, Tbilisi, 3rd Delisi st. 22 A, Tel.: 31 37 18.
Ministry: Ministry of Gas Industry, "Soiuzburgas", "Soiusburgeothermy".

Authors: N.B. Tsertsvadze, F.D. Anastasidi, N.S. Kotrikadze, O.Sh. Vardigoreli, B.I. Vashakidze, L.G. Ananiashvili, G.M. Abuladze, T.G.Kiknadze, H.A. Chkoidze, L.R.Vachiberidze.

178 pages of assessment of operational resources (capacity) of the thermal water in Zugdidi - Tsaishi deposit (Republic of Georgia). 105 pages of text appendixes, 13 drawings, 47 items of bibliography.

Research Institute of Geothermy, Department "Gruzburgeothermia" , Tbilisi, October 1984.

Abstract: The area of work is in the north submersion of Georgian clod. The aim of work was the assessment of operational resources (capacity) of thermal water in Zugdidi - Tsaishi deposit in order to use thermal water in industry. The result of the research was the assessment of operational resources according to category ---
A-11500 m^3/day, B-2800 m^3/day, C-1500 m^3/day, A+B+C -15800 m^3/day, at temperature 81-88^{0}C. On the bases of the obtained data the structural plan of Aptian-Neocomian deposits roof within the deposit is determined. The investigation revealed consideravle inhomogenuity of collecting properties of Aptian- Neocomian thermal water system and also indicated the connection between Zugdidi and Tsaishi water intakes.

Key words: drilling, well, area, Zugdidi - Tsaishi, operational resources, thermal water, debit, head, pressure, level, temperature, water conductivity, piezoconductivity, thermogradient, thermal water intake.

Date	Position	Name, surname	Degree	Signature
October 25, 1984	Head of the organization	N.Ignatiev	candidate of technical sciences	
	Head of the group	N.Tsertsvadze	candidate of technical sciences	

Introduction

At present many regions in Georgia have considerable difficulties concerning fuel and energy sources. The need and deficiency of fuel will increase in the next few years.

Georgia has rich resources of thermal waters with the temperature 50-100^{0}C. It is sufficient to note that there are about 300 different outlets and deposits of thermal waters on the territory of Georgia. A definite amount of deficient fuel is compensated by using thermal waters for heating and hot water supply. One of the greatest thermal water consumers in the West Georgia is town Zugdidi and its agricultural and industrial enterprises.

In the recent years a great attention was paid to the increase of agricultural production. The main concern here was timely and sufficient supply of early vegetables to the city population. The best way to solve the problem is to build green-houses. One of the most promising regions for the development of greenhouses is Zugdidi region.

Tsaishi wells were drilled at different times by "Uglerazvedka", "Kaptaiminvod" and "Gruzneft" at the depth of 670-784 m. and thermal sources with nearly saltless water (0,6 - 1,7 g/l), with temperature 80 = 82^{0}C were discovered. Operational resources as for 1975 are according to categories category --- A-11500 m^3/day, B-2800 m^3/day, C-1500 m^3/day, A+B+C -15800 m^3/day (minnutes N 7384 dated april 29, 1975).

Zugdidi-Tsaishi deposit thermal water is used for the needs of town Zugdidi and resort Tsaishi. It was planned to design and construct a vegetable processing plant and consequently it became necessary to increase the operational resources of Tsaishi water inlet.

In order to fulfill the instructions of State Committee of Resources, dated April 29, 1975 (records N 7384) that "before the usage of C_1 and C_2 sources starts, the regions must be additionally explored...". Georgian Department of Earth Depth Heat Usage together with Transcaucasus Exploration Depth Drilling Team offered to drill a geothermal exploration well with the design depth of 2000 m. in the Tsaishi region. The recommended well was made at the designed depth of 2000 m. in the Tsaishi region. The recommended well was made at the axis of Urtinsk Tsaishi anticline, 3 km to the North of geothermal well N1 -op and N 3.

The new well N1-t, when it was being drilled from Neocome deposit, started producing thermal water with the initial debit 5500 m^3/day and temperature 82^{0}C. Water debit for today is 3800 m^3/day.

Based upon the task fulfilled by the Geological dept. of Transcaucasus Exploration Depth Drilling Team "Soiuzburgas", Transcaucasian group designed a project of additional studies of Zugdidi - Tsaishi resources. According to the project, 6 additional wells had to be drilled with total length 12 000 linear m.

Location of all exploration wells was approved by all consumers and the Ministry of gas Industry.

Industrial flow of the thermal water was received at well N 1-t with 4000 m^3 / day debit, at well N 2-t with 2700 m^3/day debit, at well N 3-t with 540 m^3/day debit. At well N 4 a repeated cycle of testing was carried out by means of compressor "UKP-80", but self flow did not take place and water level was established at 20 m. depth. At well N5 self flow was ceased by a compressor, the quantity was 1500 m^3/day. From February 27, 1984 self flow stopped and at present the water level is at 19 m. depth. Thermal water temperature in all wells varies from 81 to 87^0C. Well N6 is not finished yet.

Besides the designed vegetable greenhouse plant, main consumers of thermal water are town Zugdidi, tea factories, a poultry plant, a poultry complex that is now being built etc.

Economic efficiency of using geothermal.water in comparison with boilers is rather high. (This question is analyzed in detail in the corresponding chapter of this report).

We consider the operation conditions of Zugdidi -Tsaishi deposit as acceptable (see chapter 9).

According to the State Development Plan of the USSR the main geological exploration works of Zugdidi- Tsaishi deposit for 1981 must be finished in 1984 and the resource amount approved.

In connection with this study an assessment of thermal water resources and costs was planned by "Gruzburgeothermy" for 1984. The report includes assessment of thermal water resources according to A+B+C category and estimates the condition for October 1984.

This report concerning the assessment of operational reserves of thermal water in Zugdidi-Tsaishi deposit was made by "Gruzgeothermia" staff and a Scientific research Department of Tbilisi Scientific industrial Enterprise "Soiuzburgeothermia": N.B.Tsertsvadze, F.D. Anastasidi, M.S. Kotrikadze, O.Sh.Vardigoreli, B.I.Vashakidze, L.G.Ananiashvili, G.M.Auladze, T.G.Kiknadze, R.R.Vachiberidze and N.A.Chkaidze.

Well drilling and hydrological work was carried out by "Kolkhida" team of Gruzgeothermia" (Head of the Team A.B.Khundadze)

A lot of Zugdidi - Tsaishi deposit water tests have been carried out since 1951. Typical tests were carried out in the Central Laboratory of Geological Dept. (L.A.Borisova).

Complex analysis of water and gas was made in the laboratories of State Geological Institute of the Georgian Academy of Science (I.Natadze, D.Grigorishvili) by Complex Department chemist A.Naroushvili. Control tests of water were made in the Institute of Mineral Raw Materials (M.Kvitaishvili). Bacteriological tests were made at the Sanitary-epidemic station of Zugdidi.

GENERAL MAP OF SITE

ОБЗОРНАЯ КАРТА РАЙОНА РАБОТ

М 1:400 000

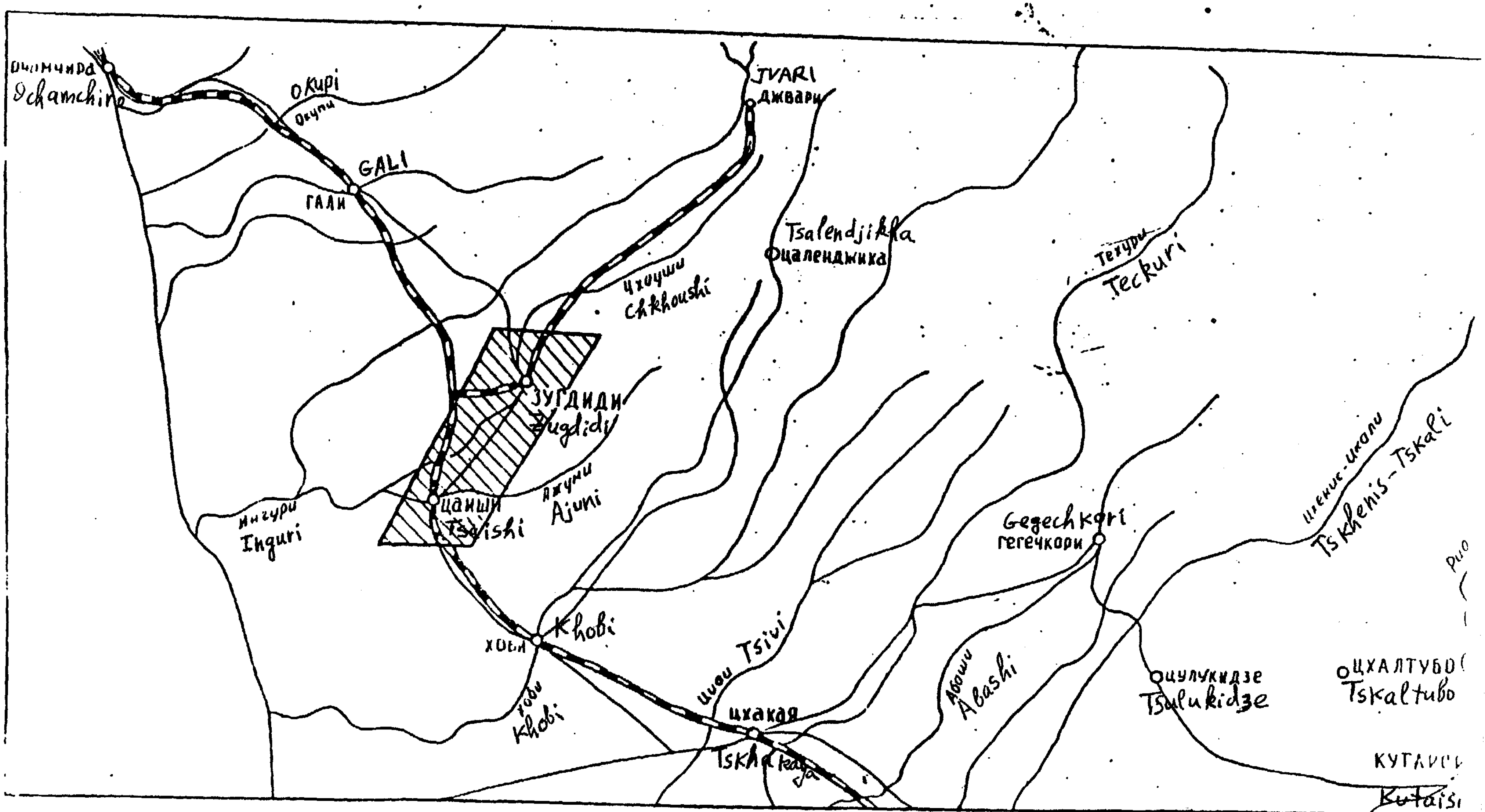

Рис.№1 Fig. 1

I. GENERAL INFORMATION ON WORK SITE

I.I. Geographical and Administrative Location of the Deposit

Zugdidi-Tsaishi deposit of thermal waters belongs to Zugdidi region of Georgia. It is located within Mengrelian artesian basin, which comprises territory of 2,400 km^2 between the rivers Ingiri and Tskhenistskali. The northern border of the basin passes across the southern slope of the Mengrelian mountain-chain, the southern border is represented by anticline folds in linked position. They are: Satanjo, Urtine, Eki, Nokalakevi, Abedati.

Water intake distance from the consumers the greenhouse complex being under construction makes 2-4.5 km. The nearest settlements are Tsaishi, Urta, Onaria, Odishi, Ingiri, etc. The large populated area on the territory of the deposit is Zugdidi which is 6 km away from the greenhouse complex. Zugdidi and the adjacent populated areas are linked with the regional centres of the Republic by well developed highways. Besides, Zugdidi is linked with Tbilisi, the capital of Georgia by railway and in Ingiri, which is 10 km away from the greenhouse complex, there passes Tbilisi-Moscow railway. (fig.1) Due to well developed communications, it became very easy to ship goods from any site of the former USSR. Well developed power transmission line system provides power supply to the site. It is easy to solve the problem of technical and potable water supply of the site within the explored water intake location.

I.2. Landscape, Climate and Orohydrography of the Region

In the orohydrographic sense, in Mengrelian artesian basin , within which there are explored water intakes, there could be found: high mountainous, almost inaccessible, landscape cut with numerous rivers, erossion-hilled, terraced landscape and accumulative plain. High mountainous almost inaccessible landscape is developed in north-east part of the region, mainly on the substraction of chalk and jurrasic depositions. High mountainous landscape bordered with hilly one from the South, passes across the lines on the surfaces of chalked lime. Absolute limits of high mountainous part vary within 1,000 and 2,500 m. In the East part there is high mountainous plateau, within which there is a mountain-chain Opitara with highest points: mountain Askhi (2 436,7 m), Chkhvinigula (2168,2 m), Matara (2020,4 m), etc. The plateau is sloped to the south and south-west directions and declines gradually down to 1000-1100 meters.

Due to extremely wide spread carsts, there are no river arteries in the site. Underground net causes drainage, which gives birth to relatively big rivers Chochkhuri and Abasha. All the rest of high mountainous part of the region is characterised by strong cut of the landscape and dense hydrographical net. The rivers are characterised by steep and rocky, almost inaccessible, sometimes even hanging slopes. The major item in the site is water dividing mountain-chain between the rivers Tekhuri and Khobi.

To the southern direction from the region there is located hilly landscape with absolute points of 600-1000 m. In the West and south-east parts of the deposit there are mountain-chains of medium height: Satanjo, Urta,.Eki, Nokalakevi and Abedati. Satanjo, mountain-chain starts from the right bank of the river Ingiri further to the North-west direction for 6-7 km. The maximum height of the mountain-chain is about 506, 9 m. Urta, mountain-chain starts from the village Tsaishi further to the south-east direction up to village Khorga, for 20-22 km. Ekis-mta mountain chain lies on the distance of 10 km from the Tsivi river canyon up to the village Saberio. The highest point is in the central part and reaches 466,6 and 408,8 m. The North slope of the mountain-chain is gently sloping and is easily accessible for observation on the whole length. The South slope is more steep producing vertical cornices of about ten meters height here and there.

In the region Nokalakevi there is distinct, in the morphological sense, mountain-chain of north-east and south-west stretch with maximum point 895 m. The mountain-chain crosses the river Tekhuri in the north-east direction gradually declining and ending, and in the south-west direction, it gradually declines and joins with Ekis Mta near the village Eki. The Abedati mountain-chain starts from the river Tekhuri at about 12 km length in north-east direction. maximum point of the Abedati is 553,3 m. The North mountain-chain gently slopes ($25-30^0$), and southwards it declines steeper by $30-40^0$.

The territory between the said mountain-chains and peripheral sites of high mountainous landscape continuation represents errosion-hilled site. Water dividing elevations located between the minor rivers draining the described part of the region basically are of north-east--south-west stretch. The absolute height of these elevations vary in the range of 200-400 m. Relative height is about 100-150 m. All the territory of the errosion-hilled landscape located southwards and southern-east anticlinal elevations represent a plain with absolute points of 30-40 meters.

Climate is subtropical in Zugdidi region, damp with warm winter and hot summer. The climate formation of the region is influenced by the Black Sea. Average annual air temperature reaches $13-14^0$ C. The coldest month is January. Average temperature in January varies between $4,5-5,4^0$ C. Sometimes it gets colder and the absolute minimum of the temperature in January reaches -14^0 C (from 1961 up to 1984, -14^0 C was recorded only once in January of 1964), (Table 1). The absolute maximum temperature in January is 22^0 C. It starts to freeze in December in the region and stops in March. Premature frosts are observed even in the end of October and in the beginning of November (as on October 17, 1957), and late frosts are in April (1948). The periods without frost are long enough, average 300 days annually. The years when the temperature does not go down below 0^0 C are quite frequent. From February the temperature goes up and reaches maximum in August. Average temperature in this month is $22,7^0$ C. Absolute maximum temperature of the air in the region is rather high and reaches 40^0 C. Absolute minimum temperature in August is 10^0C (Table 1).

The musson winds are typical for the region. In winter there are winds of east direction (winds from the ground), and west in summer (from sea). In the region there are well developed day and night winds -breezes (in daytime wind blows from the sea.

and at night-from the ground). Wind power in the region is mainly not strong -1-2 m/sec. More windy is the cold period of the year.

Precipitation falls from 130 mm to 2 300 mm annually. Precipitation mostly fall in autumn (September). Minor precipitation takes place in May (Table 3). The days with precipitation are quite frequent annually, about 160 days. Daily precipitation is well revealed in the region. Their maximum is in morning and evening hours, minimum-during the night and day hours. It does not snow regularly every year. The earliest month for the first snow is November. As a rule, it snows mainly in the first half of January. Snow cover is not high, just several centimeters (2-10 cm). The average number of days with snow amounts to 15 days annually. Abundant atmospheric precipitation, sea breeze, rich floral cover cause high air humidity during the whole year in the region. Average relative humidity varies within the range of 70-80% (see Table 2). Relative humidity is higher in the summer months due to the bogged-up areas. Out of other natural phenomena more frequent are thunderstorms, hail and mist. Thunderstorms are observed whole year round. In the winter months - average 1 day, in the summer -3-8. Hail is observed during the whole year. Hailstones are usually small and harmless. The days with hail are rather rare (average 1-2 days per year). The mists are rare, also. (Annually 30 days).

Hydrography. There is a dense river net in Zugdidi region, also many lakes and marshes. besides the river Ingiri, there are also: Jumi, Chkhoushi, Chanis-Tskali, Kulis-Kari, Munchia, Rukhi, Didgeli, Ergeta, Galentskali, Chitantskali, Mogiri, Umpia, etc. All the rivers are alimentated by rain and ground waters, the small rivers are alimentated by the marshes. Out of big rivers there could be named Ingiri, Jumi, Chkhoushi, Kulis-Kari.

The river Ingiri is composed by two rivers junction, generated from the glaciers. The length of the river is 213 km, water collecting area is 4040 km^2. Average density of the river net basin is 0,59 km/km^2. According to the level rates, it belongs to Tien-Shan river type. It has high water characteristics during the warm period of the year. Water level elevation starts at the end of March and the beginning of April. Level intensification is accompanied by the fluctuation caused by the rains. Maximum is reached in June-July. In the following period the levels gradually decline. From November to April winter level of the river is set, sometimes disturbed by thaws (in the upper reaches) and showers (in the lower reaches). The river is alimenated by snow, glaciers, rain and ground waters. More important in the total flow are thawing and rain waters. In the warm period the flow rate is 80-02% of the annual flow. The smallest flow is observed in winter and its rate is 7-8% of the annual flow.

The river Jumi starts near the village Chkondobera, at the height of 310 m and joins with Ingiri at the village Kirovo. The river length is 61 km. Water collecting area is S 79 km^2. The main tributaries are: Chkhoushi, Kulis-kari, Sintsa, Umbia. All the rest of the rivers are less than 10 km in length and concentrated mainly in the lower part of the river. The basin comprises total 234 rivers. Average river net thickness is 1.15 km/km^2. In the geomorphological sense, the river basin is divided into two parts: upper - from the source up to the village Tsaishi and the lower - from the village Tsaishi down to the mouth. The landscape of the upper part of the basin is hilly. The surface is broken up by a number of medium height hills, which decline gradually down to the river and merge with the terraces. The lower part is a plain with wavy surface broken up with a net of small tributaries. The level in the lower flow is connected with the Ingiri flow rate, which is floody in the warm season of the year. The Jumi rate is characterised by high flood, according to the questionnaire. The amount of the high flood reaches 3-5 in winter, 2-6 in spring and 2-10 in fall. It lasts usually for 2-5 days and during prolonged thaws - 10-15 days. High flood height reaches 0,9-1,4 m over the intermediate level. Level is typical for summer seasons. It is sometimes disturbed by the rain high flood (1-3 times for a season). of the height not exceeding 0,3-0,5 m.

The basic mass of the river flow is generated mainly in May or June and is caused by the joint flow of thawing and rain waters. However, there are the years when the maximum water discharge may take place in fall or the end of summer, after strong continuous showers pass. The maximum water discharge is 181 m^3/sec. (4/VII-1958), and the minimum 0,8 m^3/sec. (17/XI-1957). In summer there flows down about 16% of the annual flow. For the rest of the year the flow is distributed more or less evenly and amounts to 24% of the annual flow in spring, 23% in fall, and 37% in winter. The ice befalls rarely on the rivers, in very severe winters and for a very short period. In the upper flow the river is transparent and clear but in the lower flow it is mostly turbid during the year. It is not used for drinking. The river up to the village Tsaishi is utilised only for small village mills.

<u>The river Chkhoushi</u> is formed by Didi Chkhoushi and Patara Chkhousi river junction. The length is 33 km. Level rate of the river is of freshet type with distinguished period in summer, and the rest of the year it is summer-fall, when the low levels with the fluctuation limits within 10-20 cm are kept. There are 3-5 freshets in spring, 1-2 in summer, 3-8 in fall and 1-5 in winter. Their duration is 1-10 days and sometimes more. High freshets are in winter, spring, rarely in fall and summer. They reach 0,5-1,2 m of height over the interfreshet levels. The main supply for the river is rain waters. The river is supplied less with water after snow melting. Annual water discharge in Zugdidi is 2,22 m^3/sec. Maximum discharge is 160 m^3/sec, minimum - 0,05 m^3/sec. Low water period is summer. in summer In summer the flow is 14-15% of the annual flow. During the rest of the time flow is even and amounts to 28% in spring, 22% in fall, and 34% in winter. The ice befalls rarely on the rivers. Water is not drinkable.

The length of <u>the river Kulis-Kari</u> is 25 km, water collecting area is 45,6 km^2. There are 37 rivers in the basin. The river level rate is not studied yet. It belongs to the Black Sea river type with freshet rate during the whole year and short term unsteady river level in summer, rarely in winter. Maximum height is reached in March-April and also in winter and amount to 0,6-1 m. During several years starting from November up to January there are periods with low levels and its fluctuation reaches 0,1-0,15 m. Maximum water discharge are typical mainly for spring, and also in fall due to continuous rains. The period with the least water amount is summer and sometimes winter. The river is utilised for the small village mills and tea plant water supply.

1.3. Short information on deposit exploration and its development

Tsaishi deposit of thermal waters was found in 1951 by well No1, drilled to explore coal deposits by the company "Kavkazuglegeologia". The well is 824 m deep. During the drilling works with 707 m height in the barrem lime there was obtained thermal water self-flow-out with initial temperature up to 60^0C. At the depth of 710 m water temperature reached 72^0C, well yield was 4,6 l/sec, water head was 15 atm. By the end of drilling at the depth of 824 m. well-yield rose up to 17 l/sec, and the temperature reached 82^0 C. Water was of chloride-sulphate, and sodium-calcium composition. General mineralisation of water was 1,7 g/l. According to the data of 1952, there were set operating supplies of the thermal waters in the amount of 2.600 m^3/daily at the temperature of 82^0C (VKZ Minutes No 7772 of November 19, 1952. Authors I. Bakradze, V. Edilashvili et al).

On the basis of the water there is built a balneological resort of the republican significance which is still operating. In 1964-1968 within the town Zugdidi there were drilled three investigation wells No 1, 3, 4 on the thermal waters with total length of 7875m. According to the results of the drilling procedures, in 1969 there were calculated operating supplies of the thermal waters and were set in GKZ in the amount of 6,800 m^3/daily by category B with the right for design (GKZ Minutes No 5746 of August 15, 1969, reports made by Sh. Chubinidze, G.Liparteliani et al.). By the request of Department of deep ground heat utilisation Ministry of as Industry, there was worked out the feasibility report on thermal water utilisation for heat supply of the production enterprises and residential houses in Zugdidi, Georgia, by the Institute of Engineering Equipment TsNIIEP.

According to the rated annual economic efficiency of thermal water utilisation in comparison with heat supply from conventional boilers using coal as fuel, makes 465.000 roubles. In the following years there have been undertaken regular geological research of thermal waters resulting in new deposit exploration in Samtredia, Menji, Rechkhi, Saberio, Kindghi, by Geological Department of Georgia. In 1974 according to the results of geological-research works executed in 1968-1974 in the West area of submersion of the Georgian clod, there are calculated and set the operational supplies of thermal waters amounting to 98652 m^3/daily by categories $A+B+C_1$, including categories A+B=23896 m^3/daily (GKZ Minutes of USSR No 7384 of April 29, 1975, report compiled by Sh. Chubinidze, G. Liparteliani et al). From 1975 besides the Geological Department which continues to explore thermal waters on the territory of Georgia, a large amount of deep drilling works are performed by Georgian Department of Exploring Drilling and Thermal Water Extraction (at present it is called "Gruzburgeothermia"). In particular, to implement decisions of Council of Ministers of USSR, the said department established research in Kindgi and Okhurei sites. Exploration was executed also, at Tsaishi-Zugdidi site by means of 6 investigatory wells with total depth of 12685m of deep drilling. In 1983 Zugdidi-Tsaishi deposit supplies were submitted to GKZ USSR (Minutes No 9405 of December 28, 1983) for approval. However, due to unfinished preliminary exploration, absence of necessary material for thermal water discharge justification, GKZ USSR thought it premature. The present report is compiled considering all comments and suggestions.

2. Short Characteristics of Geological Structure and Hydrogeological Conditions of the Region

2.1. Location of the Region in the General Structure of Georgian Territory

Zugdidi - Tsaishi thermal water deposit is located in the west part of the Georgian clod, which is a part of the Transcaucasian median mass.

The Transcaucasian inter mountain region (late Baicalian median mass) is divided by Adjaria - Trialeti fold zone into Georgian Artvino-Bolnisi and Azerbaijan clod, the boundaries of which have fold regions and are deep occurrence faults that have been developing for a long (11).

Georgian clod occupies inter - mountain depression between Grate and Small Caucasus in the elevated part of which crystal substrate - Dziruli massive is seen. To the west direction clod is extended to the Black Sea region, while in the East it is extended to Mtkvari depression.

Georgian clod is divided into Western and Eastern submergence zones, central elevated zone and Okrib - Kheta zone (10).

Western or Kolkhida (molasse) submergence zone, except for its north boundary, consists of quadrant and Neogaean molasse deposit that covers weakly dislocated carbonate Cretaceous deposit and lower Paleocene. It is divided into a number of blocks (Gudauta, Samurzakan, Odishi, Ochamchire and Abasha).

Zugdidi - Tsaishi thermal water deposit is located in the region of two subzone contiguity - Odishi and Kolkhida. In their geological structure, as in the neighboring Gagra- Djava Zone of the fold system of the southern slope of Grate Caucasus, there are rocks from lower Jurassic to modern (draw.1).

Older formations, crystal foundation rocks (Precambrian and lower Paleozoic) are exposed beyond the region limits.

2.2 Stratigraphy

Jurassic system
Lower part
Liassic stage

Liassic deposit - is represented by the sandy schistose formation of upper Liassic with maximum capacity 1000 m.

Litologically it is formed by stratification of mica sandstone, aleurolite and dark argilliths. Thickness of sandstone interlayers differs from several cm. to 3 m. and the thickness of their packs - from 1 - to 30 m. and more. Rocks of this age are exposed in the northern part of the region, in river beds: Inguri, Tekhuri, Khobi and Tskenis Tskali.

Medium Part

A wide line of middle Jurassic deposit is extended at the surface within Okumi elevation and by a number of features is divided into Bathonian and Bajocian stages.

Bajocian Stage

Bajocian deposit is a porphyritic suite, outlets of which are in the canyons of rivers Tekhuri, Khobi, Tskenis-Tskali, Chanis-Tskali, Magani and Inguri.The suit is embedded on upper Liassic sandy schist formation and changes into coal bearing Bathonian suite in the upper part. In places where the later is missing, it is transgressively embedded by deposits of mixed color upper Jurassic suits or carbonate deposits of lower Cretaceous period.

Porphite suite is represented by tuff, tuff breccia and porphite coating. In the upper part of the section there are terrigenous formations of tuffaceous and greywacke sandstone, tuff conglomerate, argillith and mixed color clay. Lithological composition changes are typical for the suite in horizontal and vertical profiles and everywhere the suite has intense dislocation. The most complete section is exposed in Inguri canyon, where it forms several large folds. Total thickness of the suit is 260m.

Bathonian Stage

In the Bathonian stage deposit, coal bearing suite is exposed only in river Magana basin, where it is evenly imbedded on the porphit suit and is transgrassively coated by upper Jurassic mixed color suite deposits. Lithologically coal bearing suite is of gray green and dark gray color, small granular, rarely clay, often quartz - graywacke sandstone, sand clay schist with coal schist interlayers or stone coal lens; stage thickness is 200-250m. According to the opinion of some explorers coal bearing stage is missing in the work area.

Upper Part
Kimmerian Tithonian Stage

Upper Jurassic deposit consists of mixed color suite which is transgressively imbedded on porphite and coal bearing suit horizons covered with carbonate rocks of lower Cretaceous period. Lithologically they are represented by carbonate sands, breccia and conglomerates with limestone of calcareous marl, tuffolava and basalt covers, while in the upper part of the section they are represented by lens and interlayers of gypsum. The suite has mixed color in which red is dominant.

The suite is well exposed in river Magana canyon where its thickness is 600 - 650m. To the East the suite thickness increases till 1000m. and then abruptly decreases. In Chanis - Tskali canyon the thickness is up to 150 - 200m in Khobi canyon 30 - 40m. Stripped thickness of upper Jurassic deposit in Tsaishi well N1 is 758m.

Cretaceous system
Lower part
Neocomian upper stage

There are Cretaceous deposit beds in places of Bajocian formation above the Kimerrian -Tithonian mixed color suite. They have all stages from Valanginian including Danian.

Lower Cretaceous formation is divided into three parts: Neocomiane upper stage, Aptian and Albian stages. The carbonate Neocomiane deposit itself has tree suits.

Neocomiane lower part (Barrias Goterivian stage) is represented by bedded light gray cryptocrystal, dolomite, cracked limestone with gypsum interlayer (2 - 3m).

The terrigenous part of rocks in heavy fraction contains pyrite, limonite, pyroxene, biotite, muscovite and hornblende. In light fraction newly formed plagioclase reaches 70%

The Medium suite is represented by the Barremian stage Urgon facies. The stage consists of massive, thick layer, fractured, crystal and dolomatized limestone.

The upper part of the section that belongs to the upper Barremian stage consists of bedded, marl, pelitomorph limestone.

The heavy fracture of the Barremian stage terrogenous mixture consists of pyrite (20-38%) magnetite - ilmenite (till 30%), monocline pyroksene (till 20%), horneblende (40%). There are a few circone, tourmaline, limonite, biotype. The light fracture consists of plagioclase (10-70%) and clay particles (30-90%), also quarts, volcanic glass (5-20%) and flint fragments.

On logging diagrams Neocomiane deposit are separated in high resistance packages pk = 250 - 500 + 1000 - 1250 ohm).

Neocomiane deposits are exposed in all prospecting wells drilled within Zugdidi-Tsaishi deposit where the thickness reaches 832 -865m.

Neocomiane thickness in central Megrelian anticline north wing is 700-750 m. and in mountain complex Askhi - 500-550 m.

Aptian Stage

The deposits of this stage evenly follow Barremian limestone in the increasing reserve. and on their part are evenly covered by Albian deposits. Aptian rock outlets are stretched in an uninterrupted, narrow line along the North flange of the central Megrelian syncline. To the East they are continued at Mountain Complex Askha (r.Chachkhuti canyon) and occupy a comparatively large space. To the South they sink and are exposed only by drilled wells. In Mountain Complex Askha they are represented by light gray limes, rich in fauna ammonites and belemnits: The thickness is 30-35 m.

In the North wing of Central Megrelian syncline and left bank of r.Khobi the thickness is 30 m. To the West the thickness increases till 65 m. (in r. Magna and Inguri canyons). Lithologically they are represented here by light-gray dense marl and limestone.

The dimensions of Aptian deposit seeming resistance are 50-250 ohm.

Albian Stage

This formation evenly substitutes Albian formations and is evenly covered by Cenomanian.

In the North East wing of the central Megrelian syncline Albian stage is represented by marl, marl clay and marl lime layers of 100-110 m thick (r.Magana canyon). To the East Albian deposit can be traced in the canyons of all rivers that cross the Northern part of the central Megrelian syncline. Lithologically the constitution does not change.

In Urta (Tsaishi) and Satanjo anticlines Albian stage is represented by clay and clay sandstone and clay marl which are followed by tuffaceous-glauconite sandstone in the upper part of the reserve (from 1 to 3 m. interlayers). According to the well data the revealed thickness at Tsaishi region is 600 m. In Eksa and Nokalakevi anticline Albian Stage is represented by interlacing beds of marl clay, sandstone, various tuffs and basalt tuff breccias with rare interlayers of clay lime. The thickness is 220-240 m.

According to the data of prospecting well N2 drilled in Satanjo anticline, the thickness of Satanjo anticline dome part is 405 m. The value of resistance coefficient decrees and is 15-35 ohm.

Upper Part
Cenomanian Stage

Cenomanian uninterrupted deposit can be found from r.Tskhenistskali canyon to r.Inguri canyon and further to the West. It evenly follows Albian deposit and is evenly followed by turonian limes.

In most of the sections (r. Inguri, Chanis tskali, Magana) Cenomanian stage is represented by gluconit sandstone, marl limestone and marl; the thickness is 40-50 m.

Within Eksa and Nokalakevi anticlines Cenomanian stage is represented by alteration of sandstone, gluconit sandstone , marl, marl limestone, porphit tuff sandstone, tuff breccia with teschenite stratum vein and basalt cover. The thickness is 100-120 m.

In Kolkhida subzone Albanian Cenomanian deposits were revealed in all wells where they are represented by clay and tuff-lime-marl and tuffaceous sandstone 500-550 m thick. The whole Albanian Senomanian layer has low resistance coefficient (5-35 omm), which easily distinguishes it on logger diagrams among high resistance, upper and lower Cretaceous rocks.

Turon Danian Stage

On the whole territory of Megrelian artesian basin Turonian deposit evenly follows Senomanian sediments and gradually changes into coniacian. Deposits of this stage are well distinguished and fauna is characterized in Satanjo anticline line and its North East part. Lithologically they consist of alternating white-gray marl lime and thick yellow-gray lime.

In the North part of Central Mengrelian syncline there is 800-1000 m thick Turon-Danian sediment section which begins with a thin layer, dense organogenic lime with red flint inclusions. Further it is followed by thin layer lime, marl lime and marl with gray flint concretion and fauna of Santonianian and Companian stages. Above there are crystal and marl limes, marls of Maastrchtian and Danian stages. In Urta anticline Turon Danian deposits are 300-400 m thick and consist of carbon facies . In the North-East wing of Urta anticline, near village Tsaishi, Turone is 170 m thick.

Coniacian-Santonian-Campanian Upper Stages

In the North wing of Central Megrelian syncline the most complete section of this deposit is revealed in river Chanistskali canyon where a rock is evenly distributed above glauconite marl and limestone. It consists of thin bedding pelitomorphic dark gray lime, thin light-gray lime with concretion and red flint lens, pelitomorphe lime, in some places of lithographical type with chalk lens and fauna. The deposit thickness here is 574m.

In river Ingury canyon lower part of this deposit consists of laminated, thin layer light-gray lime and marl lime with gray flint, which have (0,5 - 1,5 m) marl interlayer; the section finishes with lime and marl lime. Total thickness here is 400 - 500 m.

Maastrchtian-Danian Upper Stage

Maastrchtian-Danian deposit participates in the structure of the North wing of Central Megrelian syncline. Its thin line can also be found along Abedati, Nokalakevi, Eksa,Urta and Satanjo anticlines. The deposit is well revealed in river Chanistskali canyon, where lithologically it is represented by thick bedding lime and massive lime, which in the upper section is substituted by medium and thin layer lime, thickness is 183 m. Maastrchtian-Danian deposit can be found from river Chanistskali canyon to the West, stripping in r.Inguri and r.Magna Canyon. This deposit is well stripped in river Hobi canyon.

In the East parts of Odishi Subzone and mountain complex Askha subzone, in the upper Cretaceous layer, reserve volcanic suit Mtavri occupies a large part, which consists of Tuff breccia, tuff, tuff sandstone, tuff conglomerates with interlayers and lime and marl lens. Suite age in Eksi, Nokalakevi and Gordi-Djushi anticline is Turon - Coniacian - Santonianian and in Abedati above lower Turonian, maximum thickness is 500-550 m.

In the region of Kolkhida plain, Turon Santonianian deposit in the whole has lithological similarity with deposits of anticline elevation lines Eksa and Urta. Thickness at Kvaloni part is 430-450 m. and in Chaladidi-Kulevi - 200-270 m. There are no Danian deposits in Kolkhida valley. Resistance coefficient of upper Cretaceous lime is 40 - 500 omm.

Paleogene and Neogene systems

Paleogene and Neogene deposition is widely spread within Megrelian artesian basin. It is revealed on the whole territory of Central Megrelian syncline and in Satanjo,Urta, Nokalakevi and Abedati anticline elevation.

Paleocene - lower Eocene

A narrow line of the deposit of this age can be found from river Inguri canyon to the East till river Tskhenistskali. Isolated outlets of those deposits can be found in Satanjo, Urta, Eka, Nokalakevi anticline elevation. In Urta and Eksi anticline zone this deposit is transgressively embedded on Cretaceous sediments while on all the other territory of Central Megrelian syncline it evenly follows Danian suite deposit.

In the North part of Central Megrelian syncline the section begins with thin bedding marl line, with marl interlayer that contains Paleocene microfauna. Above there is lime with marl interstratum and microfauna of Neocene. The thickness is 50 -30 m.(r. Inguri canyon near village Jvari) The described rocks, preserving their lithological composition and thickness can be found from Inguri canyon till river Magani, Chanistskali and Zobi canyons and are 45 m thick. Lime composition decreases further to the East and is of a secondary significance. The thickness is - 50 m.

Within Eksi, Urta and Satanjo anticline Paleocene (thickness 60 - 85 m) consists of massive, thick bedding and crystal lime, which is transgressively embedded on Danian suite, while in Eksi anticline - on different horizons of upper Cretaceous suite.

Zugdidi prospecting wells stripped this deposit at 810 - 1000 m intervals (well 1), thickness - 187 m. In wells N3, N4 they were not found.

Medium Eocene. within Megrelian artesian basin Medium Eocene deposit evenly follows lower Eocene and in places is transgressively embedded on different horizons of Paleogene and Cretaceous suite. It is represented by complex, crystal lime that has nummulitic fauna. Deposit is stripped in river Hobi canyon (North part of Central Megrelian syncline) and consists of alternation thin bedding lime marl of green-gray color with clay marl (65m thick). Deposit of medium Eocene can be found from river

Hobi canyon to the East and West. In western direction thickness of medium Eocene deposit decreases and reaches 30 - 40 m in river Inguri left inflow Olory canyon. In well sections drilled within Zugdidi this deposit is not found as an independent unit.

Upper Eocene is evenly embedded on medium Eocene deposit and is evenly covered by Maicop series. Rocks are represented by marl and seldom by clay, which are revealed on the North part of Central Megrelian syncline in river Hobi canyon. Here they are represented by mild sandstone and lare marl of light-brown color with a lot of fish scale. Thickness is 132 m. In South-East direction, in river Khuro, Ochkhamuri,Tekhuri canyons an increase of lime interlayer is seen be decrease of clay mass. Full section of upper Eocene can be found in river Inguri and Olori where Foraminiferral marl is evenly embedded on medium Eocene deposits, 30 - 40 m thick. Above there is a following section: thin schistosity marl with fish scale, unlaminated green-gray marl, clay Khadum horizons. General thickness 90 -100 m.

Resistance coefficient of Paleocene and Eocene deposit changes from 5 to 400 oms.

Oligocene and lower Miocene (Maikop series)

In the Eastern part of Central Megrelian syncline and in Abedi and Nokalakevi anticline Maikop series, 800-900 m thick are evenly embedded on upper Eocene and are evenly followed by Tarkhan horizon. Section of this deposit in river Chanis Tskali (right bank) is represented by alternation of dark-gray and brown-gray clay, friable light-gray sandstone, grauvak sandstone and marl, rich in fauna that shows Oligocene age. The thickness is 650 - 800 m.

Maikop series deposit is discovered in the East in Hobi, Ochkhamuri, Tekhuri and Chachkhuri canyon. To the East the quantity of sandstone decreases and the quantity of clay increases. To the West the deposit crosses river Magana and Inguri canyons and spreads to Abkhazia.

In Eksa line (30 - 150 m), Urta and Satanjo (150 - 600 m) anticline, Maikop series is trasgressively embedded on different horizons of Eocene and chalk and is transgressively covered by Chokraki.

In Zugdidi prospecting wells Maikop deposit is revealed in wells N1, N4, its thickness varies from 148m to 98 m.

Resistance coefficient does not exceed 20 ohm.

Medium Miocene

It begins with Tarkhan horizon, which is stretched along the North part of Central Megrelian syncline, in river Chanistskali canyon. Medium Miocene thickness is 31 m. to the West in river Inguri Canyon the horizon is represented by alternation of thin bedding and yellow clay, sandstone clay and sandstone. In the East of river Chanistskali this deposit can be found in the canyons of r. Khobi, Khuro, Ochkamuri etc. Rock thickness in this direction decreases and reaches 6 m.

Chokraki horizon - in the North East part of Central Megrelian syncline is evenly embedded on Tarchan horizon and evenly transfers into Karagan deposit. The best section of Chokrak can be found in river. Chanistskali, Khobi, Khuro, Ochkhamuri, Tekhuri, Chochkhuri. In river Chanistskali canyon thickness is 505 m. Lower part 9220 m) is represented by thin bedding carbonate clay. Sandstone plays a secondary role and the rest of the deposit consists of sandstone and clay alternation.

In Nokalakevi, Eksa and Urta anticlines Chokrack is represented by clay-marl facies. In most of the sections of Northern part of these folds Chokrak (120-170) is evenly embedded on Tarklain horizon and is evenly substituted by Karagan or is transgressively covered by Pontic. In the South part of these folds Chokrack is Transgressively embedded on different Paleogene horizons and trangressively covered by Pliocene. The thickness varies from 30 - 150 m.

Karagan horizon in the whole area is evenly embedded on Chokraki horison and covered by horse or transgressiely by younger deposits.

The most complete section of Karagan horizon can be found in river Khuro canyon, thickness is 182 m. Lithologically it consists of blue-gray and gray different grain mica quarts sandstone, with gray carbonate clay and marl interlaiers. This deposit is distinctly seen in river Khobi canyon. The thickness is 160-170 m. In the South East the deposit is stretched in an uninterrupted line along East end of Central Megrelian depression and further along North-East part of Abedi anticline. Thickness is 350-400 m.

Horse horizon is located along the North part of Central syncline. In river Khobi canyon the horizon consists of thin grain gray sandstone, bedding sandstone clay with interlayers of thin conglomerates and lime. Thickness is 83 m. In river Khuro one can find the full section of this deposit.

Upper Miocene (Sarmatian)

Sarmatian suit deposit is widely spread on the territory of Megrelian artesian basin. The existence of lower and medium Sarmatian sub suits is proved faunistically. In the South part of Central Megrelian syncline, lower and medium subsuits are represented by clay facies and have 120 - 200 m and 280 - 300 m. thickness accordingly. In the North part of Central Megrelian syncline they are represented by strong sandstone, sandy clay and gypsum clay with conglomerate interlayers 250 - 300 m and 700 - 750 m thick.

Resistance coefficient of medium and upper Miocene varies from 5-20 till 100-250 omm.

Pliocene

In Pliocene deposit, the existence of meotian, Pontic and Kimmerian suits are faunistically established. They are represented in two faciess - conglomerate and clay sandstone.

Conglomerates (to 300 m) are found in the North part of Central Megrelian syncline and fill its wide mound. Clay sandstone facies is developed in the anticline elevation of Eksa - Urta - Satanjo. Conglomerates from North to South gradually become thin gravel and finally are substituted by sandstone clay formation.

At the border of Central Megrelian syncline lime conglomerates trangressivelly, with angular unconformity cover different Miocene and Oligocene horizons, while in the synclinal fold they are embedded in the mound on medium Sarmate.

In the South part of Eksa, Urta, and Satanjo anticline Pliocene is represented by clay sandstone facies, while conglomerates can be found in the form of singular interlayers and packs. Thickness is 200 - 500 m. In Kolkhida subzone a full section of Pliocene is stripped, which is represented here by clay sandstone formations, 800 - 2700 m thick.

Resistance coefficient is 20 250 omm.

Quadruple system

Within Central Megrelian syncline quadruple deposits are widely spread and represented by alluvial, delluvial, elluvial and marsh formations. Alluvial deposits of river terraces in valleys of all main rivers are especially widespread. Lithologicaly they are represented by conglomerates, that mainly consist from porphite suite rocks. pieces of different granites, diabase, tuff sandstone, mildly cemented sandstone. clays and loams. Thickness of these deposits reaches 250 m. These deposits do not have a definite stratigraphic disposition and are soon substituted in horizontal and vertical directions.

2. 3. Tectonics

This region includes Odishi subzone of North sinking of the Georgian clod. The North east part of Megrelian artesian basin, where feed zones are located, belongs to Amzar-Mukhur subzone of Gagra- Java zone of fold system of Great Caucasian South slope.

Odishi subzone is one of the most distinctly expressed geostructural units of West sinking of Georgian clod. It includes Central Megrelian syncline and surrounding like a curtain Abegati, Nokalakevi, Eksa, Urta and Satanjo anticlines.

To the North Odishi subzone borders with Amzari-Mukhuri subzone fold system of Caucasian range South slope. To the East it borders with Askha mountain complex subzone. From the West and South with Kolkhida subzone of Georgian clod. Border with Anzar-Mukhur subzone is simultaneously a border between Georgian clod and fold system of Great Caucasian South slope. Border with mountain complex Askha

2.5.6. Water resistant deposits of upper Eocene and Maikop series

To these deposits refer mighty thickness (900 m) of upper Eocene of unschistisic, thin layer of marl and Maikop unschististic gypsum bearing clay, which are water resistant roofs of water bearing complex of upper chalky and paleogenic lime and water resistant bed of water bearing miocenic deposit complex. Despite this, upper eocenic marl, as well as Maikop series clay in the upper weathering part contain underground waters in insignificant quantity. Spring discharge near marl amounts to 0.1-0.3 l/sec. Water mineralisation fluctuates within 0.2-0.6 g/l. Chemical composition of the waters is hydrocarbonate-magnesium-calcium, seldom it is sulphute-hydrocarbonate-magnesium calcium-sodium with increased mineralisation.

Of insignificant water bearing quality is weatherworn part of Maikop clay. Spring discharge fluctuates within 0.01-0.1 l/sec. Mineralisation of waters does not exceed 0.5-0.7 g/l. Chemical composition of the waters is sulphute-hydrocarbonate magnesium-calcium, or hydrocarbonate-sulphute-calcium-sodium.

2.5.7. Water bearing horizons of Paleogenic and Chalk deposits.

The deposits are represented mainly by carbonate facies in the folds of the Mengrelian reservoir. Intensive cracks, karsting features and abundance of atmospheric precipitation cause strong augmentation of the deposit. Water bearing complex is made up with marl-clayey formation of apt-cenomen, water resistant roof is made of marl and clay-sand deposits of the upper Eocene and Maikop series.

Water bearing complex is characterised by vividly revealed horizontal srtatum of hydrochemical zoning.

In the karst and karst-crack water circulation area (intensive water exchange area) there are fresh hydrocarbonate waters, which along the slope of water bearing complex from the north-east to the south-west are substituted by chloride-hydrocarbonate calcium water going to high mineralised chloride-sodium waters. The mountainous Mengrelia. "Askhi mountain complex" serves as feeding source. Intensive cracks and wide development of karst forms cause high level of water abundant rocks in the area of active water exchange. In the area of upper chalky and paleogenic deposit bedding (in the river Eristskali, Inguri, Tekhuri, Tskhenistskali and other river gorges) one can see numerous exits of karst springs of large debit (from 0.1-some hundred liters per second), of sharp fluctuation.

Waters of this area are weakly mineralised (0.2-0.5 g/l), hydrocarbonate-calcium. more rarely sodium-calcium. Water temperature is between 7-16^0 C. The chemical composition and mineralisation of these waters depend on spring discharge. Karst spring waters are used for the drinking purposes for the population. The low water exchange area contains pressure waters. Chemical composition is chloride-sodium with general mineralisation up to 1.5-26 g/l. These waters contain hydrogene sulphide in small amount. These waters are mainly of methane type. To this horizon there refer sulphide chloride-sodium mineral waters of Menji, Tsiashi, and Bia. They are located 3 km to the west from the town

Senaki (Tskhakia) at the peryclinic ending of Ex and Urta brakhianti-clinic folds. The medicinal properties of theses waters are known from ancient times.

Menji sulphide water (well No 5) is characterised by the following chemical composition:

$$H_2S_{61}\,M\ \frac{Cl\,96}{Na93}\ t\,31^0\,C$$

The reserves of this water were exposed as a result of numerous exploring works and approved by GKZ in 1981 in the amount of 762 m^3/day by category A.

Chemical composition of mineral spring Bia is of chloride-sodium type:

$$M_{9.0}\ \frac{Cl\,90\ HCO_3 6}{Na\,96\ Mg\,2}$$

In the well drilled in 1967 ("Gruzgeologia") in the village Satsuleiskiro, westwards from Aek anticlines from lime of the upper melapaleogene there was extracted mineral water of the following chemical composition:

$$M_{2.5}\ \frac{Cl\,87\ SO_4 12}{Na\,77\ Ca\,22}\ t\,36^0C$$

The tsaishi sulphide mineral water (well No 9) is of the following chemical composition:

$$H_2S_{25}M_{2.0}\ \frac{Cl\,82\ HCO_3\,18}{Na\,93}\ t\,36\,^0\,C$$

As a result of exploration works in 1978, the operating supplies of the Tsaishi sulphide waters had been determined and approved by GKZ in the amount of B-80m^3/day and C_1-120 m^3/day (Report No 8269 of 18.04.1979).

The Nakalakevi mineral springs are located on the left embankment of the river Tekhuri. The spring exit is related with upper Eocene lime of the north wing of Nakalakevi anticline. With the level rise of the river, the spring level is risen also and consequently discharge and composition of the mineral water is being changed. D-300-800 m^3/day. T-25-31^{0}C. Water belongs to chloride-hydrocarbonate-magnesium-calcium type. Mineralisation is up to 0.4-0.5 g/l.

2.5.8. Sandstone tuff waters, tuff breccia and lime, sporadically developed in the eruptive rock thick of the Mtavari suite (turon, santon)

These deposits are spread beyond the limits to the south of the region-under-consideration. Under them are bedded tuff breccia as lenses and lime containing small amount of underground waters.

The spring discharge of these strata due to their sporadic bedding is insignificant and does not exceed 0.01-0.1 l/sec. Chemical composition of water is hydrocarbonate-magnesium-calcium and sodium type. General mineralisation is within 0.2-0.7 g/l. Atmospheric precipitation feeds this horizon.

2.5.9. Water resistant deposits of Apt-alba and Senoman.

These deposits are widely spread in the region. They are regional water resistant complex between water bearing horizon of lower chalky lime and water bearing complex of upper chalky and paleogenic deposits.

Lythologically they are clay-marl deposits with interlayers of sandstone and lime.

Within the Kolkheti artesian basin and in the stripe of Eki-Nakalakevi anticline, these deposits are enriched by eruptive material. But as the marl and clay are dominating in these deposits, they could be viewed as water resistant.

The spring debit connected with the upper weatherworn zone of these deposits is within 0.1-0.3 l/sec. Water mineralisation does not exceed 0.7 g/l. Chemical composition of the water is hydrocarbonate-magnesium-calcium.

2.5.10. Water bearing horizon of lower cretaceous deposit

Lower cretaceous water bearing horizon is developed on large surface area within the Mengrelian, Kolkheti and Kodori artesian basins. The whole complex of the deposits is thick lime rock with abundant water features. Water resistant bed of the horizon is represented by clay deposits of colored kimmeridge-titon suite, in some places there is porphirite bios suite. Water resistant roof is clay-marl deposit of apt-cenomen. Lower cretaceous limes are developed on the plateau "Askhi mountain complex", Kvire. Okhachkue and others. Atmospheric precipitation amounting to 1500-1800 mm per year generate strong flows of the underground waters, water flows in the direction from the north to the south-east.

The rocks of lower cretaceous are cracked and karst and that's why they are water abundant. Out of the complex of rocks we could distinguish karst, karst-cracked and karst-layer circulation of underground waters. Great part of karst and karst-cracked declining springs is related to active water exchange area. Flow discharge of non-deep circulation occurs at the river gorges: Olori, Inguri, Khobi, Tekhuri, etc. Spring debit has wide range from 0.1 up to 20 l/sec and above. Some exits generate rivers.

Chemical composition of the underground waters of active water circulation area of lower chalk is hydrocarbonate-magnesium-calcium. Mineralisation is 0.3 g/l. Temperature is - 5^0C -16^0C. The water regime is very variable caused by uneven distribution of atmospheric precipitation during the year. These waters are significant supply for future water supply of the Mengrelian regions.

Cracked stratum circulation waters, i.e. those of lower activity water exchange are head type, of weak mineralisation and high thermal qualities, up to 100^0C, hydrocarbonate-sulphate-calcium composition.

The feeding area of this horizon is located in the north wing of the central Mengrelian cynclines (2000 m). Further, lower cretaceous limes bedded between water resistant layers of albe-cenoman and upper jurassic layers are sunk southwards and in the central part of artesian reservoir down to 2,500-5,000 m. The big difference of the feeding and discharge grades resulted in high pressure of thermal waters of lower cretaceous horizon.

In the lower cretaceous deposits thermal and high thermal waters of Rechkhi. Tsaishi. Nokalakevi, Zugdidi, Menji, Bia, Khobi (table 4) have been uncovered by wells. By the well "Cavkazuglegeologia" in Tsaishi there had been extracted pressure mineral waters of 82 ^{0} C temperature on the 700-750 m depth, their composition is hydrocarbonate-chloride-sulphate-sodium-calcium with general mineralisation 1.5-1.7 g/l with total debit 24 l/sec (IV-1965). Chemical cimposition of water is:

$$H_2\,S_6M_{17}\ \frac{SO_4\,53\ Cl\,32HCO_3 15}{Ca\,45\ Na\,40}\ \ t\,81^0C$$

On the major part of the Megrelian basin there are fresh waters of hydrocarbonate-magnesium-calcium composition with mineralization 1 g/l. In the south-west and south peripheral places of the basin the mineralization increases up to 2,5 g/l and water becomes of sulphate-chloride-calcium-magnesium-sodium composition. Southwards within Central Kolkheti artesian basin, the mineralization keeps on increasing in the region of Chaladidi, Kvaloni reaches 31-75 g/l, chemical composition changes into chloride-sodium-calcium (Fig.2).

Tsaishi and Nokalakevi waters are used in resorts places for medicinal purposes. in the places below they are utilised in the greenhouses.

Mineral waters of lower cretaceous horizon contain gas mainly of atmospheric origin. that indicates the intensive water circulation. In the southern part of the Kolkheti Plain beyond the screening break-up, there prevails methane in gas content (Kulevi. Chaladidi. Kvaloni). proving hydrogeological isolation of the horizon in this region. (4.5.6, Table 5).

2.5.11. Water resistant deposits of colored suite of kimmeridge-tyton and sheety shales and sandstone of bat

Upper, weatherworn part of this deposit has water bearing qualities. In this complex water is beared by cracks with tectonic dislocations and weatherworn ckracks.

Waters are spread in colored suite and circulating in the stratum rich in gypsum. they have increased mineralisation (up to 1.5 g/l) and of hydrocarbonate-sulphate-calcium composition. In difference with them bat deposit waters are of low mineralisation (up to 0.5 g/l) and hydrocarbonate-calcium composition.

2.5.12. Water bearing complex of eruptive deposits of bios

The rocks of this suite are intensively dislocated and cracked. that causes the abundance of water. Cracks with tectonic disorders and also. weathered cracks have water bearing qualities in this complex. The springs are related to the weathered cracks and have small debits 0.01-0.3 l/sec. More abundant waters are in the tectonic crack springs and talus-prolluvial origin, the debits of which amount to 0.5-6 l/sec. Water mineralisation of the intensive water exchange area is 0.04-0.8 g/l T=4-10^{0}C. Chemical composition of the water is hydrocarbonate-magnesium-calcium.

Underground water area of low water exchange are related to the said complex, mainly of high mineralisation 50-95 g/l, of chloride-calcium composition. T=17^{0}C. Lugela refers to them as well. It is used for the curative purposes.

Well	Gas composition	% volume		Gas composition cm^3/l
1	2	3	4	5
1-Rechkhi	88,3	11,7	-	41
3-Zugdidi	58,9	41,1	-	24
4-Zugdidi	55,6	43,5	0,99	33
1-Tsaishi	61,1	36,0	2,9	-
4-Tsaishi	82,9	15,7	1,4	20
2-Nokalakevi	81,4	18,6	-	30
21-Kvaloni	27,5	46,0	26,5	-
3-Chaladidi	-	1,0	99,0	-

The source is 6 km away from the village Mukhuri, on the left embankment of the river Khobi. Water is 9,5% solution of chloride-calcium. Debit amounts to 22.000 l/day. T=12-0-C. Bromide composition up to 0.18 g/l. By means of the wells there were injected non-deluted chloride waters of high mineralisation (50-240 g/l), of Lugela type (Gumurishi, Tskhunkuri) on the depth of 1,500 m. Debit is insignificant 0.01-0.2 l/sec.

Mineral water of Skuri is in the gorge of the river Chanistskali 19 km away from the regional center of Tsalenjikha. Water oozes from the crackes in tuff brecchia bios. Water is of sulphate-chloride-calcium-sodium composition. Mineralisation is 1.9 g/l. Debit of water amounts to 80,000-100,000 l/day. Radioactivity - 1.5. "Skuri" water is used for water supply and drinking purposes.

2.6. Geothermal conditions of the region.

One of the main sources of information in geothermal researches is temperature measured in the wells and mountain mines. For general purposes there are used also,data of carotage measuring of temperature.

Most of the metered wells of the republic are located at the territory of West Georgia, where there is Zugdidi-Tsaishi deposit, the subject of our study.

In Tables 6 and 7 we give temperature data of upper and lower chalk roofings, which are main water bearing horizons of thermal waters of the region-under-consideration. (The Tables are obtained from the book "Geothermal conditions and thermal waters of Georgia") (3).

In forming the temperature field of arch shaped bent anticline ridge, the most significant is the heat transfer through convection. In the areas near the village Tsaishi there was identified the highest anomaly temperature up to $62^{0}C$ at the depth of 650 m. (3).

Central Mengrelian syncline, located north-eastwards from Zugdidi-Tsaishi deposit is not studied thoroughly, though its geothermal significance is obvious. Surface waters leak within the north wing of the Central Mengrelian syncline sinking gradually in the mould syncline and then come out into anticline ridge made of carbonate rocks of chalk, causing Tsaishi thermal anomaly.

Temperature distribution of Chalk horizon roofing

Table 6

Name of the well	Depth of bedding	Temperature
Menji, 2	420	26,12
Zugdidi,1	600	43,89
Zugdidi,3	1000	92,24

Temperature distribution of low cretaceous horizon roofing

Table 7

Name of the well	Depth of bedding	Temperature	Notes
Menji, 2	1260	47,10	
Zugdidi, 1	1440	67,40	
Tsaishi, 1	650 2085	72,5 90,0	There were two units injected

I. M. Buachidze (4.6) thinks, the Mengrelian syncline a is thermal buffer for anticline ridge. According to temperature distribution in the sunk layers of deposit covers, most interesting are the isothermal surface maps of $+50^{0}C$ and temperatures at 1000 m section. (see figure 3 and 4).

isothermal surface $+50^{0}C$ is located at various depths and at 1000 m section temperature change is within wide range. (3).

The cooling effect of the Black Sea tend to general sinking of isothermal surface from the ground to the sea, (In Sochi at the depth of 2000 m, in Sukhumi-Ochamchire at the depth of 1600 m). On the map-section this influence is shown in temperature fall to the sea direction (picture 4).

Geotectonic and hydrogeological factors influence on the geothermal field is different ways. Hydrogeological factor causes local anormalies. On the maps there well depicted Tsaishi anomaly, where isosurface of $+50^{0}C$ rises up to 200m. Less abnormal case is marked in the centre of the Kolkheti plain, where influence of local structural effect is present. Isosurface of $+50^{0}C$ is elevated up to 1200, 1400 m, and at the 1000 m section temperature rises from 40 up to 50 ^{0}C at the same time. (see Pictures 3 and 4).

Geothermal gradient distribution data on the territory of Georgia (3) have showed. that the gradient varies in the wide range from 6,9 (Tsaishi 1- with the interval 730-1790 m) up to 75 (Tsaishi 1, with the interval of 100-500 m) (Tables No 10.8).

3.ANALYSIS OF THE OPERATING WATER-INTAKES REGIMES REGIME WITHIN ZUGDIDI-TSAISHI THERMAL WATER DEPOSIT.

Water-intakes, functioning within Zugdidi-Tsaiahi thermal water deposit, are represented by isolated thermal wells, drilled not only for studying of thermal water bearing capacity of the apt-neocom deposits, but also for other purposes. So, Tsaishi well N1, drilled in 1951, was installed for investigating the coal-carrying capacity in the given area, and wells N1-op and N3 Tsaishi, drilled in 1963-1973 years - for studying oil-gas carrying capacities. Together with drilling exploration-wells for oil, since 1963 the drilling for thermal water began - well N1-a, installed instead of operating well N1which went out of order.

Since 1979 by department "GRUZBURGEOTERMIA" the preliminary exploration works were performed within the deposit area. 7 wells - N1-t, 2-t, 3-t, 4-t, 5-t, 6-t, 8-t - Tsaishi were constructed. Hydrodynamical studies performed at that period have shown interrelation of Zugdidi and Tsaishi water intakes.

Tsaishi wells water-intakes, drilled for studying oil-gas-carrying capacity of the region have in their system 426, 299, 219, and 168 mm casing columns, besides they have indicated tectonic fault for the corresponding area . The productive complex of apt-neoco deposit is opened up by the wells at the full capacity. The wells, drilled for thermal water before 1979 have in their consruction only one column of 127mm, which is descended down to the roofing of apt-neocom deposits and have opened them up by thickness of 200-280 meters. As for the wells, finished on the stage of preliminary exploration works, in their construction there are casing columns, with the diameter 299-219mm. The latter were descended down to the roofing of apt-neocom deposits, opened up not for the full thickness but only 500-800m.

The wells of Zugdidi water-intakes have in their construction 426, 299 and 919 mm columns. The latter were descendeddown to the top of neocom deposits, uncovered at the whole thickness only in two of them , in a third one- on the thickness of 1400m.

All the operating wells which have been functioning without anypumping, only by artesian discharge. According to the data of certain wells (for example N1-op Tsaishi) their operating period is about 20 years.

The development of Zugdidi-Tsaishi thermal water deposit has started in 1952 by putting into operation the well N1 in Tsaishi with the debit of 1470 m^3/day at temperature 82^0category (alt=29m) and N4 Tsaishi with the debit of 1980 m^3/day at temperature 82^0c (alt=80m).

Afterwards, according to the completion of drilling the following wells were put into operation:

Well N1a Tsaishi (Alt=30m)- 1964; Q=940m^3/day T=82^0c
Well N1 Zugdidi (Alt=129,5m)- 1965; Q=2140m^3/day
T=$82{,}5^0$c P=1,8 kg/cm^2.
Well N3 Zugdidi (Alt=93,9m) -1966; Q=7120 m^3/day
I=86^0c P=3,3 kg/cm^2

Well N4 Zugdidi (Alt=96,35m) -1968; Q=1380m^3/day
I=68^{0}c P=0,7 kg/cm^2
Well N1-op Tsaishi (Alt=34,8)-1974; Q=2260m^3/day
I=82,5^{0}c P=6,4 rg/cm^2
Well N3 Tsaishi (Alt=34m) -1974; Q=2300m^3/day T=84^{0}C
I=6,22 kg/cm^2.

According to the regime observations and test measuring it was determined that the well-debits from the very moment of their putting into operation were changing and by 01.01.74. amounted to :

Well N1 Tsaishi -630m^3/day, well N4 Tsaishi - 660m^3/day, well N1a Tsaishi- 734 m^3/day; well N1 Zugdidi - artesian discharge is ceased and the water level is on thegrade of 26m (the result of Zugdidi N3 well installation), the well N3 Zugdidi - 5100 m^3/day, well N4 Zugdidi - 1500m^3/day.

The analysis of the regime of the long term development of the deposit shows, that putting into operation of the new wells, at the lower grades , as a rule, causes the debit decrease and the ceasing of artesian discharge in the wells, which were put into operation earlier, having highergrades of offing. An example is the fact, that from the moment of putting into operation of the well N1-op in Tsaishi (Alt-34,8m) in February 1974, Tsaishi N4 well (Alt-80m) debit began to fall down and in May , same year, the artesian discharge has completely stopped. In September, N3 Tsaishi well (Alt=34m) was put into operation , which caused Zugdidi N3 (Alt-93,9m) well debit decrease and Zugdidi N4 well debit decrease with final ceasing of artesian discharge (01.05.75).

The above examples make obvious, that the wells having Hypsometrically lower location have a negative influence on the wells with higher absolute grades.

The results of scheduled observations and multiple hydrodinamic researches (32,33) carried out during the period of years 1974-1981 have shown , that starting from 1976 for the all operating Zugdidi-Tsaishi deposit wells, complete stabilization of hydrogeological parameters was established, which continued up to June. 1981 (i. e. before experimental discharges on the newly-drilled wells N1-t, 2-t and 3-t Tsaishi:

Well N1 Tsaishi -Q=720m^3/day T=81^{0}C Pset .=5,75 kg/cm^2
Well N3 Zugdidi - Q=4700 m^3/day T=89^{0}C P_{set}.=2,78 kg/cm^2
Well N4 Zugdidi -negative level of water (-13,6m)
Well N1-op Tsaishi-Q=2250 m^3/day T=82^{0}C P_{set}=64 kg/cm^2
Well N3 - Q=2300 m^3/day T=83^{0}C P_{set} =6,2 kg/cm^2
Well N4 Tsaishi -negative level of water.
Well N4 k Tsaisi -Q=600m^3/day T=81^{0}C, P_{set}=5,75 kg/cm^2
(The well is analogous to the liquidated well N1 Tsaishi)

At the end of July 1981 in the process oftest works, the testing-industrial operation of wells N1-t, 2-t, and 3-t has srarted, having corresponding debits 5500, 5000 and 790 m^3/day. As a result of exploration works, carried out during the period of -July 1981 -

august 1983 it was determined, that the optimum variant of Zugdidi-Tsaishi deposit exploitation with the N1-t, 2-t, 3-t wells excludes the operating of the uncontrollable operating wells N1-op and 3 in Tsaishi which went out of order. In this case the unlimited operation of the deposit, for an unlimited period, is possible only under the condition, when the total water collection makes up to11020m^3/day.

According to the 1.08.84 situation, Zugdidi- Tsaishi deposits of thermal water are characterised by the following hydrogeological parameters:

Well N1 Zugdidi - negative water-level -60m
Well N3 Zugdidi - negative water-level -12m
Well N4 Zugdidi - negative water-level 33,3m
Well N1 -op Tsaishi -Q=1700m^3/day T=82^{0}C
Well N1-t Tsaishi - Q= 3900m^3/day T=86^{0}C P_{set}=3,5 kg/cm^2
Well N2-t Tsaishi - Q= 3000m^3/day T=85^{0}C P_{set} =3,5kg/cm^2
Well N3-t Tsaishi -Q=600 m^3/day T=82^{0}C P_{set}.=1,80 kg/cm^2
Well N8-t Tsaishi -Q=6100m^3/day T=84^{0}C P_{set}=4,2 kg/cm^2

As noted above, Zugdidi -Tsaishi thermal water deposit industrial development has begun in 1952. It's productivity has decreased from 3450 m^3/day and by 1964 amounted to 1565 m^3/day (well N1 and N4 Tsaishi). In 1964 the well No.1a inTsaishi was installed and during the same year the productivity which was equal to 2505 m^3/day, didn't change. From 1965 new well N1 Zugdidi with the debit of 2140 m^3/day was put into operation, as for the earlier operating Tsaishi wells N1, 4 and 1a up to 1966 their debits respectively amounted to 925, 665 and 907m^3/day. So, the productivity of Tsaishi deposit was 2497 m^3/day, and Zugdidi deposit - 2140m^3/day. During 1966 some debit decrease of Tsaishi wells was observed, relating to the putting into operation of new well N3 Zugdidi with Q=7120m^3/day. Their total debit decreased down 3220m^3/day and the debit of the new well N3 didn't change being equal to 7120m^3/day. Consequently the productivity of Tsaishi deposit became equal to 2385m^3/day, and Zugdidi - 10340m^3/day.

During 1967, no new well was put into operation; The total debit of the Tsaishi water intake for this period didn't decrease too much (only by 35m^3 /day). As for the wells of Zugdidi deposit, sharp debit decreases were observed here. For December the debit of Zugdidi deposit-well N1 decreased from3220 down to 1123 m^3/day, and the well N3 debit - from 7120 up to 6947m^3/day. By the end of the year the artesian discharge on the first of them had stopped, and on the second one it stayed the same. By 01.01.68 Zugdidi deposit productivity became equal to Zugdidi deposit well N3 debit.

During 1968 Zugdidi well N3 was switched to the limited operation regime (3456m^3/day) with the aim to rehabilitate the well N1 operation. However,no positive results were obtained. In October of the same year Zugdidi well N4 with debit 1380m^3/day was put into operation. As for Tsaishi wells, for that period there was observed the gradual debit decrease. Tsaishi deposit productivity, made up from total debits of wells: N1-734 m^3/day, N4 - 657 m^3/day and N1a-691m^3/day - for 01.01.69, amounted 2020m^3/day, and for Zugdidi depozit - 4836 m^3/day.

It is necessary to note , that from the beginning of 1969 well N3 Zugdidi was turned back to the previous operating-regime.

Up to 1974 within Zugdidi- Tsaishi deposit no new wells were put into operation. According to the 01.01.74 situation the debits of operating wells had changed in the following way:

Well N1 Tsaishi - Q=630m^3/day
Well N4 Tsaishi - Q=760m^3/day
Well N1a Tsaishi -Q =734 m^3/day
Well N3 Tsaishi -Q =5100 m^3/day
Well N4 Tsaishi -Q=1500m^3/day

Consequently, Tsaishi deposit productivity for that time made up 2024m^3/day.and Zugdidi -6600m^3/day.

In February 1974, the new well N1, with the debit of 2260m^3/day on Tsaishi deposit was put into operation. From the moment of it's installation, on the well N4 Tsaishi the debit decrease began and in May of the same year it's artesian discharge stopped completely. In September well N3 Tsaishi with debit 2300m^3/day was installed. The putting into operation of this well caused to the well N3 Zugdidi debit decrease to 4800m^3/day and the ceasing of artesian discharge on Zugdidi well N4 by the end of the year. As for wells No.1 and No.1a Tsaishi, their debits practically didn't change. So, by 01.01.75 Zugdidi and Tsaishi deposits' productivity made up 5910 and 4800m^3/day respectively.

In 1975, the debit changes on the wells N1-op, 1a and 3 Tsaishi were not observed , as for the well N1 Tsaishi it was quickly eliminated after drilling and putting into operation of the well No.4k Tsaishi , which was its complete analogue (Q=620m^3/day). On the Zugdidi deposit during the year there were observed no changes and its productivity made up 4800 sm^3/day , and Tsaishi -5910m^3/day.

During the period of January 1976 -June 1981 no important changes happened in the productivity of water intakes , with the exception of the fact that Zugdidi N3 well debit decreased by 100m^3/day, and N1a, 1-op and 4k Tsaishi wells' debits by 10, 10 and 20m^3/day respectively. So,the productivity of Zugdidi and Tsaishi water intakes by 01, 07, 81 made up 5870 and 4700m^3/day.

It is important to underline, that the sharp changes in Tsaishi- Zugdidi deposit well debits during the above-mentioned period is explained by the changed requirements of consumers using thermal water in different quantities. Analysing the sharp changes in debits for the period of July 1981 -June 1983. It is appropriate to remark that here the reason is not only tye costumer, but also hydrodinamic researches with the help of experimental-industrial exploitation of newly-drilled wells N1-t, 2-Tsaishi and 3-Tsaishi. It should be noted , that the participation of the indicated wells caused the considerable debit decrease on the well N3 Zugdidi - from 4700 to 2500m^3/day.

In July 1983 at the well N5 artesian discharge of thermal water (83^0) was obtained in the quantity of 1500m^3/day. In the middle of July during the drilling process from the well No.8 the artesian discharge with the debit of 1600m^3/daywas obtained, which continued up to 28/VIII-1983 , i,e to the finishing of drilling and the well-head furnishing. In august 1983 the work for elimination of the uncontrolled well N3 Tsaishi had started. The well was completely opened and the water with debit of 2400-4600m^3/day was pouring out up to november 1983. For october 1983 well N8 debit was 7000m^3/day, afterwards it began to decrease. Until August 1984 the debit was fluctuating within 6000-6500m^3/day limits and for 1.08.84 changed to 6200m^3/day. On the 22th of February 1984 the well N3 Zugdidi and 25-th of February well N5 stopped artesian discharge, which probably was caused by the discharged of a great quantity of thermal water (in average up to 9000^m/day) from the wells N3 and 8 on the lowest level of Tsaishi area and by the operation and water discharge from all the deposit wells (1-t, 2-t, 3-t, 8-t) in 15300m^3/day quantity.

The analysis of discharge variations during the operation of Tsaishi-Zugdidi deposit of thermal water shows, that by putting into operation of new wells, the changes of pressure on the functioning wells was observed. So, for example, the initial pressure at the wells N3 and 4 Zugdidi made up respectively 33 and 7 metres.

Putting into operation of Tsaishi wells N1-op and 3 in 1974 caused the gradual fall down of discharge pressure as a result of which on the well N4 Zugdidi by 1981 the water level established on the mark -13,6m, and on well N3 Zugdidi - 17,8m. At the same period, the pressures of the wells N1-op and 3 Tsaishi practically didn`t change. The putting into experimental-industrial operation of newly -drilled wells N1-t, 2-t, 3-t Tsaishi caused the sharp fall of pressure throughout the whole deposit. The results of scheduled observations showed, that for 01.09.83 total watercollection of 11020 m^3/day; the pressure on the well N3 Zugdidi stabilized and was equal to 12 metres, while on the wells N1-t,2-t, 3-t Tsaishi - respectively 39,40 and 18,5m.

The temperature regime and chemical composition of thermal water during Zugdidi - Tsaishi deposit operation practically didn`t change.

4. THE SCOPE, METHOD AND QUALITY OF HYDROGEOLOGICAL PROSPECTING AND TESTING WORKS

In 1950 by the department "GRUZUGLERAZVEDKA" wells N1, 1a and 4 were drilled in Tsaishi, in 1952 operating reserves according to categories: A -1500m^3/day, B - 450m^3/day and C_1 -650m^3/day were approved by VKZ. In 1966 a the general prospecting plan of thermal water artesian basins in Georgian SSR for 1966-1968 was compiled. According to this project during 1966-1968 in Zugdidi area 3 prospecting wells were drilled which have exposed thermal water. In 1969 operating reserves of Zugdidi deposit thermal water of 6000m^3/day, with temperature 72-67^{0}C, of category "B" with projecting permission were approved by GKZ (report N5746; 15 august, 1969).

For uncovering additional resources of Zugdidi- Tsaishi thermal water deposit, and for providing their combined use in Tsaishi-Zugdidi greenhouse economy and in Zugdidi residential economy , the necessity of converting thermal water operating reserves into higher categories arose. For fulfillment of GKZ decision, 29, IV,1975 (report N7384) about "additional prospecting of deposits before putting into operation C_1 and C_2 reserves, the additional prospecting of Zugdidi-Tsaishi deposits has been performed.

Since the prospective wells were planned within the deposit, practically all the wells, which appeared to be productive, can be used for heat-supply to Tsaishi Greenhouse farm.

As an initial condition for determination of the necessary quantity of wells - the heat power consumption -2,55 Her kal/hour for 1Ha, was used. Consequently, for the greenhouse farm (6Ha) at first stage the total heating power of 15Gkal/hour will be needed, which corresponds to the thermal water of the investigated deposit 8100m^3/day.

Since the main consumers of thermal water are situated directly in the north-west part of the pericline of the Urt(Tsaishi) anticline, consequently, it is most reasonable from the economical point of view to carry out the prospecting drilling of the 14,311meters depth (wells N1-t, 2-t, 3-t, 4-t, 5-t, 6-t and 8-t)

The place for bedding prospecting wells was chosen with the account of: favorable geological- hydrogeological conditions of the region, location of main consumers (vegetable greenhouse farms), and also the nearness of the power source and existence of spare area suitable for constructing of drilling installations together with their services.

Well drilling was conducted by means of rotoring by the machine "BU-75e".
The following wells are drilled and put into operation: 1-t, 2-t, 3-t, 4-t, 5-t, 6-t and 8-t.

For studying geological-hydrogeological section of wells and their bringing down to the necessary depth the appropriate drilling construction and diameter was used: 299mm for casing of the Miocene section upper unsteady part, 219 mm technical columns with cementation for isolation of tertiary, Chalk and Alb depositions, deposited higher than Neocom water-bearing complex. Neocom deposits were drilled by open stem.

While drilling the systematic monitoring of washing liquid parameters was carried out: specific weight, viscosity, water yield, crust thickness, and also temperature and clay mortar absorption. In case of clay mortar catastrophic absorption, water washing was required.

In drilling process for studying lythological composition and statigrafical horizon particles, temperature regime, water-baring capacity and the condition of wells along the whole trunk, the whole complex of productive-geophysical works was carried out.

The complex of geophysical works was carried out basically before putting into operation of casing pipe.

In the process of drilling of wells N1-t, 2-t, 3-t, 6-t and 8-t because of complete absorption of Neocom limes, it was necessary to switch to washing by technical water, which caused thermal water artesian discharge, with the exemption of wells N5-t and 6-t, and the further drilling of wells had to be stopped.

After getting artesian discharge from the wells at different tamping, debit and temperature measurements were done, and after installing the well offing by the fountain accessories the pressure was measured, and the samples of thermal water for chemical analysis were take.

On well N4 after sampling works the artesian discharge is not obtained, because its productive horizon is not uncovered. Sampling was carried out by lowering the level with the help of "UKP"-80 compressor.

Artesian discharge is not obtained also on the well N6. Presently it is used as the monitoring well . The water in it is on the level of 9 m.

Only one object was tested in all wells, being located in jointy limes of Neocom..

In the wells which had no artesian discharge of thermal water, the interval of the object testing finally was determined according to the technological-geophysical researches. The latter were performed by the group of the department "SOYUZGASGEOPHYSICA". The studies carried out by them enabled to perform stratigrafical break up of the uncovered sections, and identify the water bearing intervals. The group of "SOYUSGRUZGEOPHYSICA" department carried out the complex of the following technological-geophysical works:

1. Standard researches by two sounds, PC
2. Inclinometry with points of measurement after 25m
3. Resistivmetry, BKS, MBK,MKZ, NGK AK
4. Caverntometry, Prophylometry, Cementometry.
5. GK, thermometry.

On the wells, which had no artesian discharge after finishing of drilling, and after furnishing the well offings by the fountain accessories and by the pumping-compressing piping, which were descended to the depth of 800m, the works of installation of wells by compressor "UKP-80" were carried out. After the water extraction the wells were investigated.

The wells were studied for determining the hydrodynamic and geothermal parameters. The methods and results of this work are given in the chapter 7.

In the process testing of each well, the samples for complete and gas analysis were selected at the maximum debit.

The hydrodynamic researches of Zugdidi-Tsaishi area in 1981 were carried out by the Transcaucasian thematic group PO "SOYUZBURGAS" of Gasprom and by thematic group "Grusgeotermia" The character of variations of debits, temperature, pressure and mineralization in the process of developing of the whole system (well N1, 4 Zugdidi 1-op, 1a, I, 3. Tsaishi, I-t, 2-t, 3-t) was monitored on the example of Zugdidi well N3 operation. From 1.1.1983 the regime observations on the deposit wells and various researching works are carried out by the complex department of Tbilisi BNIPI geoterm NPO "SOYUZBURGEOTERMIA"

On the Zugdidi-Tsishi area the temperature measurements for established geothermal field were carried out on the wells N1 Zugdidi, 4 Zugdidi, 1-op Tsaishi.

According to these observation data, and also to the thermo-researches (carotage) of prospecting wells, the uncovered section was by convention broken down into two levels with different geothermal characteristics - above Neocom and Neocom.

For the assessment of waste water injection influence on the thermal water regime of Neocom water bearing horizon, the test injection of the river water into N5 Tsaishi productive formation, and of thermal water (80^0) from the well N3 Zugdidi into the well N2-t Tsaishi has been done.

The pumping into the formation of the well N5 was carried out at 3 different regimes with the help of 4 cementing aggregates.

The results of experiment of waste water injection back into the formations are given in the chapter "Information on Zugdidi- Tsaishi deposit operating reserves".

5. GEOLOGICAL STRUCTURE AND HYDROGEOLOGICAL CONDITIONS OF ZUGDIDI -TSAISHI THERMAL WATER DEPOSIT

5.1. Stratigraphy and Lythology

Zugdidi-Tsaishi thermal water deposit is located in the south-west outline region of Megrelian artezian basin and includes the part close to the centre of Urtine (Tsaishi) brachianticline fold, where the deposits beginning from the Cretaceous period including Quaternary are present.

Original rocks in the considered area are covered by the quaternary formation cover of rivers Dzhumi, Choushi, Inguri and others. The thickness of these deposits from 5 to 30m are opened up by the drilling wells. On the boards of river canyon and on abjacent areas the original rocks are exposed to the surface. The earliest rocks, which are exposed in the arch of Urtine brachianticline, are the Alb deposits, while by drilling wells - (N1-op, 3 Tsaishi)- deposits of upper Jura on the depth of 2970m have been revealed. Tsaishi well N 3 didn't reveal the footing of upper Jura down to the depth of 4000m. The most upper part of these deposits was opened up by Zugdidi wells N1,3.

Upper Jura

On the Tsaishi well N3 in the interval of 3000-4080m, upper Jura deposits are represented by terrigenous, salt-containing layers, with interbedding multy-coloured clay-aleurolite rocks with interbedding - anhydrite, clay and gypsum. In the upper part of the layer dolomites are also observed. On Zugdidi wells the formation is represented by brownish- grey clays and aleurolites, pelitomorphic and finegranular. breccia type, gypsumised, dolomites of brownish-grey colour. The thickness of uncovered kimeridge-titon is 10-31 m.

Tsaishi wells (N1-t, 2-t, 3-t, 4-t, 5-t, 6-t, 8 -t) didn't reach the upper Jura deposits.
Cretaceous period system

Lower part
Neocom overtier

Upper Jura deposit up to the section are discordantly substituted by the powerful thickness of carbonate rocks, consisting of massive jointy-quartz dolomites and dolomitized limes. The limes and dolomites of Neocom are characterised by granular or crystal structure, more seldom pelitomorphic smashes. The rocks are characterised by light colour, varying from white to reddish-brown and light-brown colours.

Neocom deposits in the lower part are represented by flaky dolomites and dolomitized limes; in the middle part by massive and thicklayered crystal and dolomitized limes, and in the upper part- by clay limes and marls. The characteristic feature of Neocom consists of tectonic stage found between river Tekhuri and Abasha in Cretaceous and Paleogene deposit. Border with Kolkhida subzone is covered by widely spread quadruple deposit.

<u>**Central Megrelian syncline**</u> is morphologically well expressed bowl type fold with a bit waviness surface. North-East part has an arch type form with maximum bend to the North, in village Jvari region. It is an integral onocline, easily distinguished along the line Okumi, Jvari,Mukhuri, Doberazeni, Salkhino and Bandza. South-West part of the syncline is curtain like breccia anticline folds - Abedati, Nokalakevi, Eka, Urta and Satanjo, length and width is the same and equals 40 km. North-East part of this syncline and the mentioned anticlines consist of terrogenous deposits of Paleocene and its bottom consists of Miopliocene and younger continental-marine formations. North-East part of the syncline has folds of second order and dislocation with a break of continuity. Rocks that fill the basin are subhorizontally embedded.

<u>**Abedati anticline**</u> morphologically is distinctly expressed brachyfold. Direction South-West -North-West is stretched for 15 km.

The fold is elevated in North-East direction and to the East of river Absha is continued in mountain Askha region, where in Tabakela region finishes in upper Cretaceous deposit. In the West direction it gradually sinks in Karagan deposits. North-West part goes down in 30-40^0 angle, and South-East part under 70-75^0 angle. Wings of this fold consist of medium and upper Eocene, Oligocene and Chockrak deposit.

<u>**Nokalakevi anticline**</u> brachyfold with axis - West-North - North-East.

In the dome part river Tekhuri canyon vulcanogenic suite Mtavari reveals. Dips of North-West is 350^0 C under the angle 28-30^{0}C , South-East side dips under the angle 70-70^0.

<u>**Eksa anticline**</u> is an asymmetric brachyanticline. Dip of North wing is North-West, under angle 10-40, Dip of West wing of fold end South under 70-80^0 angle. Fold axis has a shape bent a little to the South. The fold is stretched for 12 km.

Western sinking of anticline in river Tsivi canyon has second order folds and dislocation with break of continuity.

<u>**Urta anticline**</u> is an asymmetric brachyfold. It is morphologically well expressed and forms Urta range that is stretched for 20 km. In the Eastern direction the fold sinks and to the West it is crossed by river Jumi and cut by river Inguri erosion. Its axes has an arch, a bit bent to the South and passes to the South slope of the range. The East end of this fold is separated from North-West part of Eksa anticline by a small syncline bending near village Sakharbedio.

North-East part of the anticline dips under angle 35-40^0 the South-West part is steeper 60^0-70^0.

Satanjo anticline is morphologically well expressed on the right bank of river Inguri. from where it is stretched in the North-West direction of river Evistsksli canyon.

To the South-East, on the left bank of river Inguri it dips under alluvium deposit and is stretched till town Zugdidi, where its deep structure is revealed by wells. Dip of North-East wing fold is 30-40^0, dip of South-West wing is 60-70^0.

Within Megrelian artesian basin there are many insignificant syncline and anticline folds of second order.(38.39.40.42.)

Within the region there are a lot of disjunctive dislocations. Most of them are formed on the North wing of Central Megrelian syncline and also in the South in the region of Satanjo, Urta, Eksa and Nokalakevi anticline fold.

Tectonic dislocation is of fault and thrust fault nature.

Tsaishi Thrust Fault discovered in well N1 drilled on the right bank of r.Jumi. near "Tsaishi" resort. At 1800 meter depth well bottom goes from lower Neocomiane deposit into Albian deposit and then the section is repeated and the thickness is 1000 m. The thrust fault was not found at the surface. Vertical thrust dip is not more than 1 km.

Menji Thrust is revealed in resort Menji region. Due to this thrust medium Eocene deposit is thrust on Maikop clays. The thrust layer is inclined to the North under 30 - 35^0 angle. Horizontal amplitude of dislocation is 150 m.

Eksa Thrust. In the South wing of Eksa anticline, in town Senaki area. a thrust is revealed that is stretched in longitudinal direction. It is also revealed in well N5, drilled in the dome part of Eksa anticline. The well went through volcanoganic suite of upper Cretaceous, Senomanian and Albian periods and enters lower Miocene clay. The thrust dips to the North under 30 - 40^0 angle, the amplitude is about 1 km.

The dome part of Satanjo anticline upper thrust is revealed and because of that Turonian limes have uninterrupted contact with sandstone and marl Neocomiane. The upper thrust is spread in North-East - South-West direction and the upper amplitude is 100 - 110 m.

2.4. Short History of Geological Development

Crystal substrate of Georgian clod was finally formed at the end of Paleozoic stage. At the beginning of Liassic, Kolkhida zone was dry land, to the North of which there was a geosincline sea, the bottom of which was gradually sinking (8, 34).

At the end of the upper Liassic sinking stopped, but from Bajocian stage renewed more intensively and was characterized by underwater volcanoes. Downward movement decreased at the end of that stage and then was substituted by upper movement. The regression increased at Bathonian stage. It was connected with organic phase.

Upper Jurassic regression connected with·Pre-Tithonianic (andidian) phase of folds, caused the formation of tectonic depression in which lagoon continental layer of multy-colored suite of a considerable thickness was deposited.

Cretaceous period starts with a transgression under the condition of general sinking. In Neocomiane period epeirogenic kind of movements are observed. Regression of Low Cretaceous sea starts in Upper Albian period and lasts till the end of Cenomanian period.

In the North part of the described area (North East wing of Central Megrelian syncline) downward movement went on uninterruptedly till the end of medium Sarmate.

In the line of South Megrelian elevations at this period pre -Paleocene (Larimine), pre- Oligocene (New Perinea) and pre -Chokraki (Shtiri) phases of folds are revealed which cause short term interruptions in sedimentation.

Upper Sarmatian (Attic) phase of folds was intensively revealed in the whole region. Meotian period is imbedded on Miocene and Oligocene and has an extreme angular unevenness, while in Kolkhida subzone it is imbedded on Eocene and Upper Cretaceous deposits.

The later Orogenetic movements took place only in the South part of the area, where Pontic deposits transgressively cover different Paleogene and Meotian horizons.

After the Pontic period the area occupied by sea becomes smaller and smaller but within the described Kolkhida subzone the sea still exists during the Kimmeridje, Kuialnits, Guria and Chaudin centuries. Later differential elevation takes place that still goes on; It is proved by the existence of many terraces.

2.5. HYDROGEOLOGICAL CONDITIONS OF THE REGION

2.5.1 The Place of the Region in the General scheme of hydrogeological zoning of Georgia

According to the scheme of hydrogeological zoning of the USSR, which was worked out by VSEGINGEO, Georgia is a part of the Crimea-Caucasia region of I order of the Carpathia and Crimea-Caucasian region.

Under hydrogeological zoning of Georgia (Buachidze, 1970) the territory-in-question comprises of two hydrogeological areas:

1. Water pressure system area of the folded zone of the Big Caucasus Southern slope, and
2. Artesian reservoir area of Georgian clod.

The former comprises regions only one of which is a part of the above territory, i.e. Svaneti cracked waterbearing system.

The latter comprises the Mengrelian artesian reservoir, cracked and cracked-karst waters and partially, the Kolkhida and Kodori artesian reservoirs of porous, cracked, cracked-karst waters.

Water pressure System Area of Folded Zone of the Big Caucasus Southern Slope

The Svaneti cracked water bearing system comprises the Kodori and Egrisi mountain-chain. Lithologically the region represents sandy-schistosic lias suite and eruptive and terrigenic formations of bios and bat formed by means of a number of large asymmetric folds of latitudinal direction. Folds are complicated by numerous longitudinal tectonic gaps. Crack waters with prevailing active water exchange areas are typical for this region.

Underground waters, due to strong landscape break-up and deposit dislocation, penetrate very deep. Water abundance of the area, depending on cracking degree and crushing rocks, is within (according to spring debits) 0,1-30 l/sec (4).

Water mineralisation of active water exchange is low, not exceeding 0,4 g/l. Water composition is hydrocarbonic, calcium and sodium-calcium.

Mineral water exits are mainly related with tectonic break-ups and arch parts of anticlinic structures and they are surface revelation of underground water zones of low water exchange, often mixed with active water circulation zone. General mineralization of water is 0,3 - 2,0 g/l. Water temperature 7 - 12^0 C, spring debit 0,51/sec. Water pressure system area is a typical province of carbonic acid waters of tectonic magma activation.

Artesian reservoir area of the Georgian clod.

It is located between southern slope of the Big Caucasus and north slope of the Ajaria-Trialeti mountain-chain and is distinguished by small absolute marks. The area is a sediment complex of mesozoic-cenozoic deposits crumpled in cover folds. In the hydrogeological respect this area is rich in great amount of relatively small-sized artesian basins.

Alternation of water permeable rocks with aquitard clayey-marl rocks together with region structure, creates favorable conditions for artesian horizon forming, Main horizons combine with chalky limes and partially to the lower paleogenic one. These horizons are separated by clayey-marl thickness of apt-senomeic deposits. Waters developed in these reservoirs, are mainly infiltrative, deeply circulating. feeding areas of these pressure horizons are the Egrisi and Codori mountain-chains and the complex of the mountain Askhi (6).

In the artesian reservoirs, vertical zoning is disordered. Under highly mineralised waters of Chalk and Tertiary deposits in the water-bearing horizons in the water bearing horizons of lower Cretaceous, there are exposed low mineralised chloride sulphate magnesium-calcium waters. Due to presence of deep-sunk water bearing horizons, the region is rich with thermal underground waters. Gas composition s homogenous, methane and nitrogen with slightest gas factor. Among the artesian basins of west zone sinking of Georgian clod, the largest is the Mengrelian artesian basin, comprising central Mengrelian syncline. The basin is of bowl shaped structure, where low chalk horizon is sunk down to 3-3,5 km below the sea level. To the north and north-east it rises up to absolute marks of 2,000 m and in the South-Mengrelian anticline range, it is risen near the surface. the latter fact causes high thermal water bedding with significant head. The Kolkheti artesian basin comprises central part of the Kolkheti plain and foothills of South-Mengrelian anticlinic range. North-west and east borders of this basin are conditional, due to gradual pass of water bearing complex into adjacent artesian basin.

The distinguishing feature of the basin is quartenary cover (400 m) of sandy-clayey and clayey formation comprising most of the territory. Quartenary deposits are underlayed by strong neogenic and paleogenic formation which are substituted in some places with chalk deposits of thickness more than 2,000 m. The main feeding region is located beyond the area and secondary one is formed by the South-Mengrelian anticlinal folds. There are fresh and mineral waters in the region. Below, we enclose specifications of several water bearing complexes and horizons down to declining section.

2.5.2 Quartenary deposit waters

On the mentioned territory, among quartenary deposits, the following water bearing complexes and horizons can be identified:

a) water bearing horizons of current river bed and flood-land alluvial deposits (river sand, gravel, shingle);
b) water bearing complex unbroken quartenary deposits marsh-ridden Kolkheti plains (clay, humus or peat, sand);
c) water of large lenses in the sand and gravel of the seaside dunes;
d) water bearing proluvium-deluvium deposits of foot-hill plume (badly processed, rudely crushed material with crushed stone sand filling);
e) water bearing complex of unbroken quartenary deposits of accumulative plain between the rivers Rioni and Tekhuri (gravel, sand, clay);
f) water bearing complex of unbroken ancient quartenary alluvial terraces deposits (gravel with loam lenses and clay, sand loam, laterits);
g) water bearing complex of unbroken alluvial sea deposits of the Kolkheti plain sunk part;
h) water bearing horizon of the Chaudin deposit (gravel, conglomerates, sand, loam, clay);

Above-mentioned water bearing horizons and complexes are characterised by varying water resistance and water abundance. High filtration features are typical for present river-channel and flood-land alluvial deposits. Well and spring debit is within 0.01-20 l/sec. most abundant is the water bearing ancient quartenary of alluvial sea deposits of bedded Kolkheti plain part (1.0-20 l/sec). Minimal inflows are formed from the Chaudin deposits 0.01-0.1 l/sec.

Present flood-plains and river-bed deposits are developed along the large rivers which are of high water permeability. Filtration ratio 100-400 m/day night. Spring debit is within 1-10 l/sec. Underground waters of this horizon are characterised by free mirror declined in the direction of river flow from North to South. Quartenary deposit waters are fresh of 0.1-0.7 g/l mineralisation. temperature is 12-13^{0}C. Chemical composition of the quarternary water deposit hydrocarbonate-sodium, chloride-sulphate-hydrocarbonate, sodium-calcium, hydrocarbonate-magnesium-calcium.

Chemical composition of water and mineralization depends on lithologic composition of the rocks, water bearing horizons and underlying layers. Water bearing horizon of quartenary deposits is fed by means of river water and atmospheric precipitation. Quartenary deposit waters are the main source of water supply of the Kolkheti settlements. In the recent decades on the basis of underground waters of quartenary formation there were installed some powerful water conduits (Nosiri). which are fed with river Techura filtrates and supply potable water to towns Poti, Tskhakaia. Abasha, etc. Among quartenary deposits, most abundant are water bearing alluvial gravel and sand, forming present flood-lands of the rivers. Less abundant are ancient gravel of loam and clay filling. Dark-grey, blue dense clay is impermeable. Less water bearing and impermeable formation form mainly the plain.

Water type in this deposits is defined by physical, geographical and geomorphologic, geological and geomorphologic peculiarities. Plain landscape, abundant precipitation, dense hydrographic network, ground mechanic composition peculiarities and also, surface slow drainage result in a wide development of high bedding ground waters which cause swamping of large areas of plain. Atmospheric precipitation filtrates, river flow and surface flow feeds ground water. Out of them the most important are atmospheric precipitation, annual amount of which is 1500-1700 mm. The most atmospheric precipitation (especially in winter period) is spent on ground water feeding.

Ground water level sharply rises from January and keeps high till April. afterwards. the level gradually falls. Level fall takes place even during summer months (it is caused by high evaporation). The lowest level of ground waters is in October. Autumn showers result in level rise which continues till January. Rate of springs being fed by ground waters depends on the rate of ground waters. Large inflows are typical for them in winter months. In summer months self-flow decreases. By chemical composition theses waters are hydrocarbonate-calcium. General mineralisation is 0.1-0.3 g/l. Water temperature depends on air temperature and fluctuates between 5^{0}C and 17-18 ^{0}C.

2.5.3. Water bearing horizons of Pontian and Meotian conglomerate

In the central part of the Mengrelian synclinal, there are Pontian and Meotian deposits and are represented mainly by clay, clay sandstone, conglomerate with lime layers. Conglomerate and cracked lime, karst, due to their karsting qualities, the latter are characterised with high water abundance increasing from top to bottom and reaching maximum at lime contact area with sarmat clay, where the minimum spring debit amounts to 1 l/sec, and it increases gradually. From east to west, the lime amount increases with karst springs of hydrocarbonate sodium-calcium composition. Water mineralisation is 0.1-0.5 g/l. temperature of the water is 10-15^{0}C.

Less water abundant are non karst cracked conglomerates and sandstone, where spring debit fluctuates within 0.1-o.5 l/sec.

In the Kolkheti plain there prevails clay-sand facies with conglomerate, sandstone and sand interlayers. In this part of the region underground waters are connected with conglomerates and sandstone. Their water bearing capacity is weak and does not exceed 0.1 l/sec. Water composition is hydrocarbonate, magnesium-calcium, rarely sulphate-hydrocarbonate magnesium, magnesium-sodium with general mineralisation up to 0.3 g/l, temperature of water is 12-18^{0}C. Deep circulation waters near sandy and sandy-conglomerate deposits with risen permeability of separate layers and packs are pressurised, thermal , chloride-calcium-sodium, hydrocarbonate-chloride-sodium with mineralization up to 20-50 g/l. Their debit is 100-700 m^3 day and night. (Kulevi and Poti wells).

The feeding of this horizon is maintained by atmospheric precipitation, river underground waters at the sites of the tectonic break-ups. By means of drilling holes of 200-500 m depth, in various places of the Plain there had been extracted good flavor quality water, which is supposed to be used as water supply for collective farms, settlements, etc.

2.5.4. Sandstone waters, sporadically developed in the thickness of water resistant clay and marl sarmat tier.

Within the central Mengrelian syncline deposits of sarmat, there are thin layers of clay and sandstone. They are practically water resistant. Separate lenses of sandstone and lime sometimes contain water, which refer to the sporadic water bearing rock group.

Sarmat deposits are gypsum bearing, therefore, waters contained in them are sulphate with increased mineralisation (0.9 - 3.5 g/l). Water abundance of the rocks is weak and does not exceed 0.1 l/sec. Spring regime is not permanent and depends mainly on atmospheric precipitation.

2.5.5. Water bearing layers of medium Miocene deposits

These deposits occupy significant area in the nucleus of Central Mengrelian syncline and its wing. The whole thickness is an alternation of deposits, containing several horizons of underground waters. Water bearing horizons are partially discharged as declining springs, and in the area of complicated water exchange, they acquire head qualities.

Underground water exits are associated with sandstone, solit lime and conglomerates. Water bearing ability of these rocks varies between 0.1-50 l/sec. The chemical composition of the waters of intermediate depth circulation is: hydrocarbonate-sodium, or hydrocarbonate sodium-calcium with mineralisation up to 0.3-1.0 g/l.

In the area of law water exchange there circulate chlorite-sodium waters with mineralisation up to 0.6-9.7 g/l.

From ancient times Tsaishi warm and hot mineral waters have been very popular. By and by the interest to this deposit has increased. According to the data obtained by Institute of Studies Resort Conditions and Physio-therapy of Georgian Health Service. Tsaishi hyper thermal properties when used in bathing tanks have great results in curing movement organs, peripheral nervous system, gynaecological and skin diseases.

Corrosion properties of Tsaishi-Zugdidi geothermal waters were studied many times (7.24). They are analysed also in works of F. Tavadze and S. Manjgaladze (24). They show that geothermal waters not processed is sufficiently aggressive in respect with carbon steel brand st.3 (Table 17).

Steel Corrosion Speed St.3 in Geothermal Waters of Zugdidi-Tsaishi Deposit in g/m^2 per hour with V=0.25 m/sec

Table 17

Wells	Test duration, hour				Corrosion evaluation by 9100 hour test results		
	2000	4500	6500	9100	degree resistant	group of resistance	corrosion type
1	2	3	4	5	6	7	8
Zugdidi No 1	0.0495	0.0421	-	0.0302	5	resistant	even
Zugdidi No 3	0.1003	0.0630	0.0548	0.0550	5	-"-	-"-
Zugdidi No 4	0.9126	0.4342	0.5392	0.5715	7	decreased resist.	uneven (erosion)
Tsaishi No1-a	0.1573	0.1057	0.9982	0.1044	6	-"-	even
Tsaishi No 4	0.1760	0.0853	0.0858	0.0805	6	-"-	-"-

Generally, according to the corrosion aggressiveness these waters could be divided into two groups. Tsaishi deposit waters of 1-a and 4 wells refer to the first group. Well No 4 at present does not have head. Water of similar composition of well No 4-k, I-op. 3. 3-t. Another non-aggressive group contain Zugdidi deposit waters of well No 1 and 3. Well No 1 has no head either. Recently there were wells No 1-t and 2-t Tsaishi, geothermal waters of which are similar with those No 1 and 4. Therefore, waters of the well refer to the first group also.

As is shown in the Table steel st. 3 corrosion speed after 9100 hour test exceeds 0.57 g/m^2. which 10 times higher allowable rate for thermal system. i.e. 0.05 mm/annually. It proves necessity of treatment of the water. At present the well has no head.

Summing up above statements we can conclude:
- in natural geothermal waters of Zugdidi-Tsaishi deposit the main type of corrosion is represented by sulphur hydrogen and carbon acid. Metal corrosion speed initially is significant and then gradually decreases and stabilises. This process is finished approximately within six months:

carbon rocks in their significant crackness cavernousness, causing intensive water abundance of these deposits. The whole neocom layer is well characterised by fauna. According to the various region investigators ' data the thickness of Neocom is 1000m.

Neocom deposits are exposed to the surface 35-40 kilometers away to the North from Tsaishi deposit, where they are represented by limes and dolomites, in which karstic is well developed.

On Zugdidi wells Neocom deposits are represented by various granular jointy dolomites, with interbedding of anhydrite and gravelytes.

The Neocom deposits are passed through by Tsaishi wells N 1-t, 2-t, 3-t, 4-t,5-t, 6-t and 8-t. An incomplete thickness of Neocom in these wells in varies within the limits of 493-863m.

Alb-Cenomanian tier

Lower part of these deposits (Alb tier) is one of the old formations exposed on the old surface within the limits of Tsaishi deposit, which creates the bridge part of Urtine Anticline . The tier is represented by the alternation of thin layered marls, medium-grained and coarse-grained sandstones of rusty-brownish colour (thickness 310m) up along the section the growth of sandstone fraction is noted.

Cenomanian deposits are well exposed on the South- west wing of Urtin Anticline, where they are accordingly embedded on Alb deposits. Cenomanian is represented here by layered carbonate fine-grained sandstones, alternated with thin layered dense marl sand-stone limes. The deposit thickness is 40-45m. In Zugdidi well (N3,4) these deposits are represented by grey and dark-grey clay marls and by marls with interlayers of lythocrystal tuffs. The thickness of these deposits in the wells N 1,3,4 corresponds to the 440, 430, 416 m.

In Tsaishi wells N 1-t, 2-t and 3-t the thickness of the deposits is correspondingly 640m, 508m, 523m and is represented by the alteration of sandstone and tuff formations.

Turonian- Danish tiers

The Chalk deposits are widely spread within the limits of researched deposits. On the surface these deposits are exposed on the south-west wing of Urtine (Tsaishi) brachianticline, where they are represented by light-grey marl limes, with occasional marl interlayers. Upper Turonian parties exposed within the limes of the north-eastern wing and the south-eastern pericline folds. Here the turon is represented by monotonous layers, occasionally thin layered, with light pelitomorphic and granular limes. The total thickness of the tier is 100-130m. The Turon tier deposits are congruently substituted by the thickness of light, soft, chalk-like limes of lythographic type. These deposits are exposed within the limits of the south-west wing of Urtine anticline (at the left bank of river Dzhumi). On them , light, thick-layered. and massive limes are bedded, which are intensively cracked and create hanging scarps along the left tributary of river Natkorisgele. Thickness 35-40m. Dated as Maastrict-dat.

In Zugdidi wells N1,3 Cretacious deposits are represented by light-grey pelitomorphic, strongly cracked, organogenic limes with very rare interbedding of clay marls and clay. The thickness of these deposits in the wells, drilled in Tsaishi (N2-t, and 3-t) accordingly makes up 100m, 150m. In the well N1-t these deposits do not exist. Here they are eroded.

Paleogenic and neogenic systems.

Paleocene, lower and middle Eocene deposits - within the investigated area are not much spread. On the Southwest wing of Urtine anticline they are almost completely eroded and covered by transgressive bedded deposits of Maykop series. only at the extreme South border are the paleocen and lower eocen deposits developed, represented by light-grey, massive, cracked, cavernous and crystal limes of thickness 40m.

To the Northeast of Tsaishi region along the Munchia these deposits begin with the lime breccia layer, with thickness up to 2m, over which the width of 50m light-grey granular limes is bedded. Higher the pack of marls with 10m thickness is bedded. The total thickness amounts 65-70m.

Deposits of Palaeocene, lower or middle Eocene, injected only well N1 in Zugdidi. accordingly replace upper Cretaceous limes. The thickness is 190m, and is represented by coarse granular, light-grey limes, with rare opened cracks. The absence of these deposit in Zugdidi (N3 and 4) and Tsaishi (N1-t, 2-t, 3-t) wells is perhaps connected with upper Eocene and Oligocene transgression (43, 46).

Upper Eocene deposits are not much spread. A small area outcrop of Upper Eocene deposits is observed on the left bank of river Dzhumi, along the new highway road. Here grey and brown marls and marl clays are exposed, containing upper Eocenian period micro fauna. These deposits, represented by Foraminiferum marls and clays in well N1 (Zugdidi), come after middle Eocene, and in well N4 are bedded transgressively on Alb- cenoman, existence of which is fixed by the micro fauna data. Thickness -78m.

Oligocene- low Miocene -The Maykop series deposits are widely spread on the Southwest wing of the Urtine Anticline, where they create the broad stripe on river Dzhumi left bank. They are represented by characterised chocolate-brown and dark-grey, Shale, non carbonate, gypsum-bearing clay with bright- yellow coating. Sometimes the interlayers of sandstone packs with low thickness. On the Northwest wing the folds of Maykop series are rarely spread, covered by bench gravels of medium quaternary terrace. Total thickness of Maykop series 150-400m.

The existence of Maykop series is determined by the well N3 (Zugdidi), where they are represented by light-grey shale clays with scales. Thickness 88-210m. Their thickness in Tsaishi wells (2-t, 3-t) -254 and 190m. Small thickness of Maykop deposits is explained by eroding chockrak transgression.

Middle Miocene. Within the Urtine anticline Maykop series deposits are irregularly covered by the Chocrak horizon rocks. They are represented by greenish-grey non carbonate-clays and marls and interlayers of fine-grained sandstones. Younger deposits of middle and upper Miocene don't exist and lower Miocene (pont) are bedded directly over Maykop series rocks and over even older deposits.

Middle Miocene deposits in Tsaishi wells (1-t, 2-t, 3-t) are represented by carbonate clays, marls, sandstones, thickness in wells are 123, 230, 73.

The Pont deposits are observed on the left bank of river Dzhumi, where they begin with 10-m pack of basalt conglomerates, irregularly bedded over Maykop clays. Upper come the sand-clay deposits with conglomerate interbeddings of thickness up to 400m.

The thickness of Pliocene deposits in wells N1-t, 2-t, 3-t amount to 143, 392, 159m.

Quaternary deposits

Within central-Megrelian syncline quaternary deposits are widely spread and are represented by alluvial , talus, alluvial and marsh formations. Particularly well spread are the alluvial deposits of river terraces, found in all main river valleys. Lythologically they are represented by conglomerates, consisting mostly of Bayos porphyrit suite, well formed by different granitoyd tuff sandstones, fragments weakly cemented sandstones, clays and limes, the thickness of these deposits reaches 50-60m. These deposits have not definite stratigrafic position and are swiftly replaced both in horizontal and vertical direction.

Tectonics

Central Megrelian syncline from the South , Southwest and Southeast is bordered by South Megrelian anticline , in composition of which are marked out wing-type located Satandzho, Zugdidi, Urtin(Tsaishi), Eka, Nokalakevi, and abedate anticline.

Tsaishi thermal mineral water is related to the Urtin brachianticline, which is traced over the Urta mountains (466,4m) on the 20-25 km distance between Tsaishi and Sagigiberio. The fold axis has the arc form, which is slightly bended to the South, passes to the South slope of the range. The Northeast wing of the Urtine anticline falls under 35-40^0, at the Northwest on 50-60^0.

In the Southwest direction from the river Dzhumi valley the fold is gradually sinking and is ended periclinely in the village Sakharbedio area in the pont layer. At the West borded of Tsaishi, the brachianticline is split by the eruption of submeridian stretch. On the lowered west block the fold extension is overcovered by powerful quaternary cover.

In the section following the river Dzhumi, over the upper Alb deposits in both wings of anticline in consecutive order are bedded: tuff sandstones and sandstone-like cenomanian limes, lime-marl turon rocks, Sezon and Dat limes, low paleogen. upper Eocenian marls, Maykop series of low Miocenian Oligocene, carbonate clays and chocrack horizon sandstones, claish-sandstone conglomerate pont formations. Maykop series and chocrack layer on the South wing, and lower Pliocene on both fold wings is transgressive.

Between the Dzhumi and Munchia rivers anticline having Southwest-Northeast stretch, is of a definitely asymmetrical structure. The Northeast wing declines under 20-30^0 , and to the Southwest direction remarkably steeper, (45-65^0) or little by little over head, and here and there is even turned over, declining in this case to the Northeast under angle of 60-80 ^{0} .

To the West of river Munchia , its arc is bedded by Chalk limes, under which, in the most elevated part of the anticline in the river Dzhumi valley near Tsaishi Senonian and Alb deposits are exposed, represented by clayish marls and clays. To the West the anticline is sinking, and its arc is composed by Chalk limes, and in the valley of river Khobistskali, by low paleogene. To the East, near the village Khorshi, anticline arc is composed by Maykop, and further by middle Miocene deposits.

An interesting material about the plutonic structure of the anticline was received by the Tsaishi base well No.1 (ch. 3728) and well No.3 (ch. 4060m).

The well (1-op) after passing through the low turon deposits, whole cenomanian, alb and apt entered into the Neocome width, represented by crystal, organogenic limes. The angles of layer decline into the depth of a given part reach $70^{0.}$ Within 1790-1800m interval the well traversed the plane of the of the eruption type and entered again into the clayish marls. Further the well passed light-grey, bluish-grey and dark-grey apt marls with glauconite grains, with pyrite veins (int.2040-2190), baremian reddish-grey and dark-grey hard crystal and organnogenic limes (up to the depth of approx.2600m), low Neocome crystal and dolomitized limes and microgranular crystal dolomites with the white anhydrite layer, on the 3000m depth the well uncovered multiicoloured suite of upper Jura, in which it was drilled down to 3728m.

Thus, with the help of the well the existence of eruption with vertical amplitude of about 550-600m was determined. The fault plane declines to the Northeast under 45-60^0.

The Urtine anticline origin is related with prepaleocene (Laramian) phase of tectogenesis, because on the fold wings the Paleocene deposits are bedded transgressively on Chalk at different horizons. The upper limit of the fold creation age is postchaudinian period, as the small rivers Dzhumi and Munchia, originating from subhorizontal bedded Chandinianporphirite conglomerates within Odishi through Odishi depression is threaded anticline antecedently.

To the North-East from Tsaishi anticline Anticline Zug didi(sizes 7, 2x2,6 km. amplitude 300 m) is located. Between these is located asyncline, on the Southwest board of which the well N 2-t is drilled.

5.2. Hydrogeological conditions of Zugdidi-Tzaisi deposit

Zugdidi-Tsaishi deposit of highly thermal sulphate water comes into hydrogeological area of Georgian clod artesian basins, and is related to the south-west part of Megrelian depression, edged from the north by caucasus foot-hills, and from the south by Satandjoy, Ek, Nokalakevian and abedenish brachianticline folds. Megrelian artesian basin itself represents morphologically clearly marked large cuplike cyncline. Which is bounded by Poty-Abedanish and Tsakaia- Tsaishi abyssal breeakings from Tskaltubo, central-Kolkhetian and Ochamchiri artesian basins. In the basin the following waterbearing and waterproof complexes are identified (drawing N1).

1. Waterproof thickness of upper Juramoltycoloured suite.
2. Waterbearing complex of low cretaceous (neocom) deposits.
3. Waterproof clayish-marl width of Apt-Alb Cenomanian.
4. Water-bearing complex of chalk-low Paleogene.
5. Waterproof deposits of low Miocenian, Oligocene and upper Miocene (3,5,19)

The given highly thermal water deposit is related to the lower Cretaceous (neocom) deposits. represented by crack-cavern dolomites, represented by crack-cavern dolomites and limes, having high collective qualities, (35).Upper Jura clays (multicoloured suite) are waterproof footing of waterbearing complex, the roofing is formed by the marl-clay Apt-Alb Water-proof deposits, and upper comes the Chalk-paleocenian waterbearing complex with subthermal mineral waters. Below is given the description of these two waterbearing complexes, based on the data of drilling wells.

The thickness of Neocome in Megrelian depression is determined to be 1000m. Uncovered thickness at Tsaishi wells N1-t, 2-t, 3-t, 4-t, 5-t, 6-t, 8-t varies from 369-755m. and at Zugdidi wells N1,3, 4 correspondingly 895, 845 and 1424m.

The Neocom deposits are exposed to the surface in the mountainous frame of the central-Megrelian syncline north wing of the absolute grades 1200-2500m, where is observed the abundance of precipitation (1500-2000mm/year), which give way to the underground water powerful streams in the neocom thick. Water flows from the north to the south and south-east, along the slope of rocks. The discharge of underground streams of intermediate circulation takes place mainly in the large river canyons as springs. the debit of which reaches 5-10 l/sek (3,5,14).

By the chemical composition this waters are of hydrocarbonate -magnesium-calcium type. Mineralization-0,3 g/l. Their temperature varies from 5^0 up to 12^0C. Precipitation affects the regime of this water. Especially big flows are observed in autumn and spring , the least - in summer and winter. (3,14)

The deep water flow comes from its feeding area to the south-west direction and they discharge into the propitious geological structures at the distance of 10 km from the feeding area.

The great difference of feeding and discharge grades assures the high pressure of thermal water. The water temperature rises due to the deep bedding of water bearing complex and to the comparatively high geothermal gradient, which reaches $3.5-4^0C$ over 100m in this region.

Different organisations, for purposes of coal, oil or thermal water production, have drilled the deep wells at different times (1951-1975) These are the wells (N 1.3.4) in Zugdidi region and (wells N1-op, 1, 1a,4) in Tsaishi, in which from neocom deposits highly thermal ($80-92^0$) water was extracted.

In 1979-1984 the prospecting works on the Tsaishi area were carried out by the department "GRUSGEOTERMIA".

The prospecting area of Tsaishi sulphate highly thermal water deposits is located on the right bank of the river Dzhumi. The absolute elevation of surface area above see level are 29-71m. For prospecting 7 wells were specified(N1-t, 2-t, 3-t, 4-t, 5-t, 6-t, 8-t) from which in wells N 1-t, 2-t, 3-t, 5-t, and 8-t gave highly thermal waters.

Well N1(N4-k) is drilled (1951) in Tsaishi on the right bank of river Dzhumi. The absolute elevation of well's opening is 29m, depth-824m. By the end of drilling (X.1951) the water debit was $1469m^3$/day. T-81^0C. Water by its chemical composition was of the chloride-sulphate-sodium-calcium type, water mineralization 1,7g/l. No systematic regime monitoring was carried out. The measurements, which were made in 1959 showed that water debit decreased to $1166m^3$/day, water temperature equals 81^0C.

Later measurements were done in 1975- 1976 and showed the decrease of debit to 608 m^3/day T-86^0C, pressure on the well offing made up 0,008Mpa. after plugging the artesian pouring (within the diameter of 20m around the well) the griffons have appeared.

In October 1981 the following measurements were made which showed the stability of debit ($626m^3$/day) and temperature (81^0c). For 1/IX-1981 the water debit made up $554m^3$/day, temperature -81^0. The chemical content of water remains permanent.

$$M_{1,59} \frac{SO_4 57\ CL31\ HCO_3 11}{Ca\ 46\ (Na+K)\ 40}$$

Later prospecting showed, that wells drilled in Tsaishi area don't affect the regime of the well N-k.

The well has opened up the waterbearing horizon on the depth of 625m. Thickness of neocom deposits - 199m. Afterwards the well number was changed to N4k.
The well cross-section and design are given on drawing 5.

ГЕОЛОГО-ГИДРОГЕОЛОГИЧЕСКИЙ РАЗРЕЗ И КОНСТРУКЦИЯ структурной скважины № 4к Цициш

Н: 29м

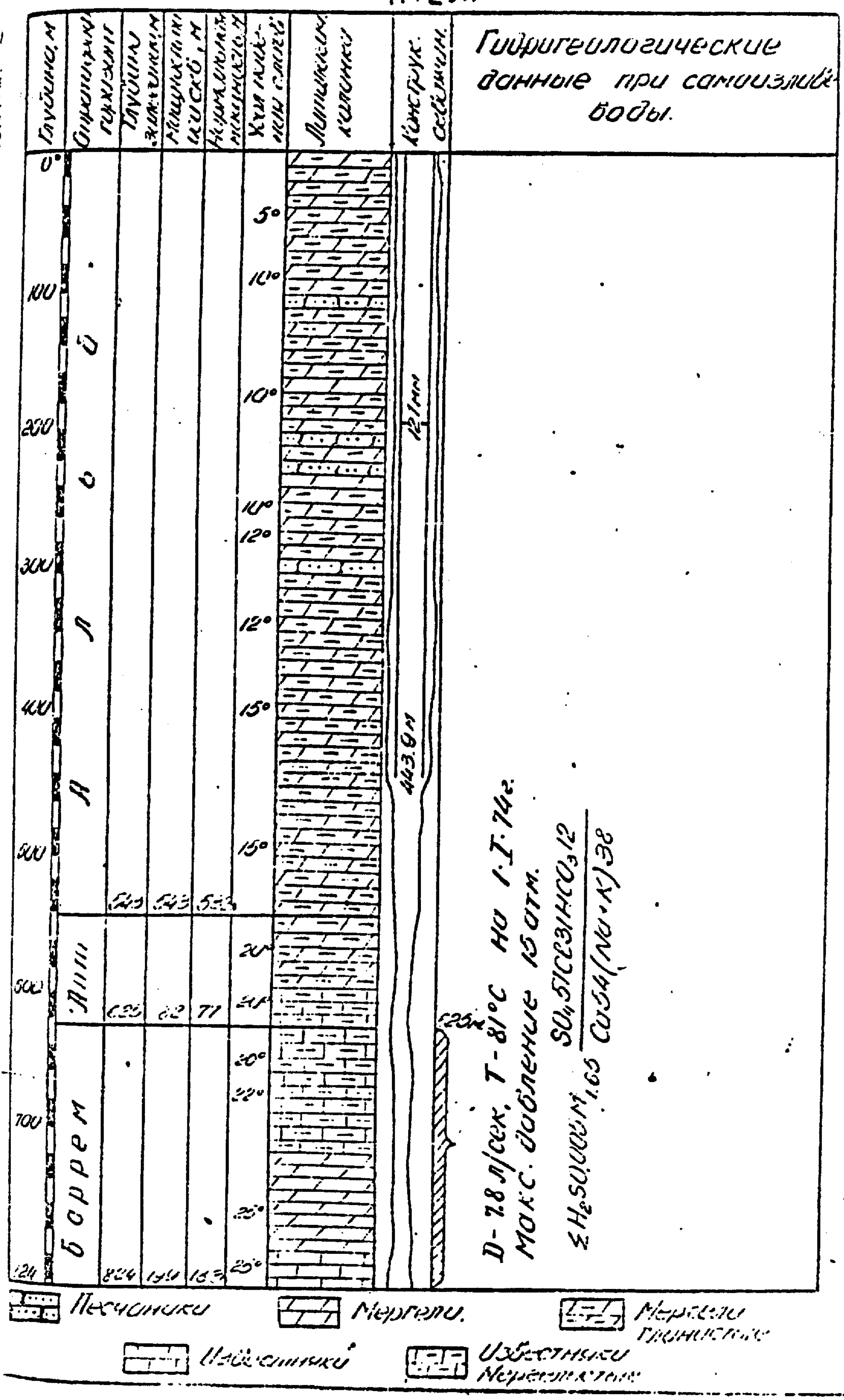

РИС 5

55

Well N4 is drilled on the left bank of river Dhzumi, in Tsaishi (IX.1952) absolute elevation 80m, depth 751m. At the end of drilling (IX,1952) the well was giving 1987m^3/day of thermal water, with 82^0 C temperature . By chemical content the water was of chloride- Sulphate-sodium-calcium type.

$$M_{1,7}\frac{SO_4 65\ CL25}{Ca\ 58\ Na34}$$

In 1953-1972 no observations were carried out. The measurements, made in 1973 showed, that the water debit decreased to 665m^3/day T-81^{0}C. The chemical composition of the water didn't change much, only the mineralization decreased down to 1,3 g/l. In 1974 the pouring of the well has stopped and the level remained on the mark 1o3m from the well offing. Afterwards no observations on the water level in the wells were carried out.

The well uncovered the water bearing horizon on the depth of 666m. Thickness of neocom deposits is 95m.

Well section and design are given on the drawing 6.

Well N1-a was drilled at the distance of 10m from well N1(4-k) near Tsaishi in 1963. The absolute elevation of the well offing is 30m, depth ... The thermal water is obtained from the depth of 543m, from neocom deposits, thickness of which here is 281m. According to the chemical composition the water is analogous to the thermal water from well N1. The initial water debit was 950m^3/day, T-81^{0}C.

In 1966 water debit decreased to 727m^3/day , T-81^{0}C. According to 1976-1981 years observation water debit stabilised and made up 757m^3/day ,T-81^0 C. The pressure at the well opening is 0,5 Mpa.

Well section and design is shown on the drawing 5.

Well N1-op (29) was drilled (1963) on the right bank of river Dzhumi in Tsaishi. Absolute elevation of the offing is 34,8m well depth 3728m. The thermal water is extracted with initial debit 1728m^3/day, water temperature 81^{0}C within the limits of 731-1790m of neocom deposits, the thickness of which is 1060m. By chemical composition the water is of hydrocarbonate-chloride- sulphate magnesium-sodium-calcium type.

$$H_2S_{0,002} \qquad M_{1,87}\frac{SO_4 64Cl26\ HCO_3 10}{Ca57(Na+K)27Mg17}$$

In 1975-1976 the debit increased up to 2260 m^3/day, temperature 82.5^0 C. Static pressure 0.65 Mpa. Chemical composition of water did not change. In the period of 1979-1980 water debit was 2000 m^3/day, temperature 82^{0}C.

In July of 1983 the well was repaired and closed. Only on the pressure was monitored, nad was on the 0.28 Mpa level with the water temperature 18-21^{0}C. For 01.11.83 the well was completely opened and at water temperature 82^{0}C it gave water of 1700 m^3/day quantity, with maximum pressure at the offing 0.35 Mpa.

Well section and design are given on the drawing 7.

Well No. 1 (Zugdidi) was drilled (1965) on the left bank of r. Chkhoushi. Absolute elevation of the well offing is 129.5 m, depth 2830 m. The well opened upthe neocom deposits on the depth of 1925 m. Their thickness along with the axis of the well is 895 m. After finishing the drilling total debit of several water bearing horizons makes up 2400 m^3/day, temperature 87^{0}C.

By chemical composition water was of chloride-hydrocarbonate-sulphate magnium-sodium-calcium type with total mineralization of 0.6 g/l (46)

$$H_2S_{0.004} \qquad M_{0.6}\frac{SO_4 44HCO_3 29Cl27}{Ca\,59\,Na23\,Mg18}$$

Two years later (1967) the well was giving a water in amount of 3000 m^3/day, with the temperature 91.8^{0}C.

By November of 1968 the water debit decreased to 700 m^3/day (influence of Zugdidi newly drilled well No. 3). Later observation has shown that thewater debit was little by little decreasing and for May 1969 the artesian flow ceased and the level remained at 33 m brlow the well offing.

In march 1976 with in order to provoke the artesian flow at well No.1 the cleaning and testing works were carried out. Artesian flow was conducted with the help of pump. Artesian flow was stopped together with the pump switching off. It was determined, that Zugdidi well No.3 affected well No.1. Later observations (1/VIII-1981) showed, that in well No.1 the water level stabilised at 46.18 m. For the 1 September 1983 the water level was 61 m below the earth surface. In 1984, according to the operation regime of the deposit the level was changing within the limits of 60-64 m.

Well section and design are given on the drawing 8.

Well No.3 (Zugdidi) was drilled in 1966 in the south-east part of Zugdidi, near the tea factory. Absolute elevation of the offing is 93.7 m, well depth 2401m. The well opened up the neocom deposits on the depth of 1525 m. Thickness of neocom deposits is 845 m. First artesian flow was obtained at the depth of 1888 m. After the finishing of drilling the debit increased to 7000 m^3/day, water temperature 91^{0}C. offing pressure 0.28 Mpa. By chemical composition the water was of hydrocarbonate-chloride-sulphate magnium-sodium-calcium type.

$$M_{0.9}\frac{SO_4 60Cl21HCO_3 18}{Ca54Na21Mg18}$$

ГЕОЛОГО-ГИДРОГЕОЛОГИЧЕСКИЙ РАЗРЕЗ И КОНСТРУКЦИЯ опорной скважины № 1 оп -Цаиши Н-34.8 м

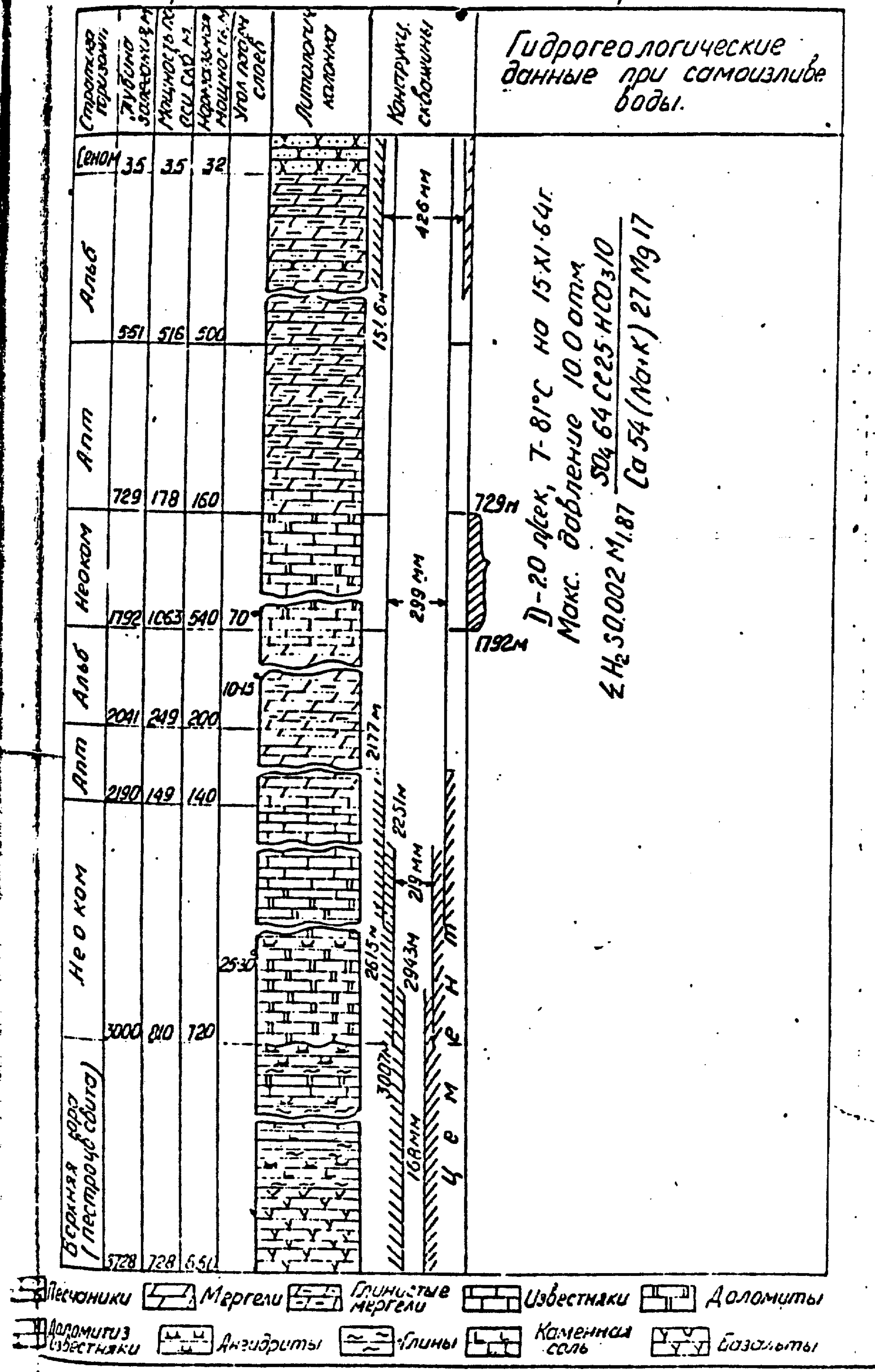

Рис. N 7

Геолого-гидрогеологический разрез и конструкция поисково-разведочной скважины №1 — Зугдиди. Н-129,5м

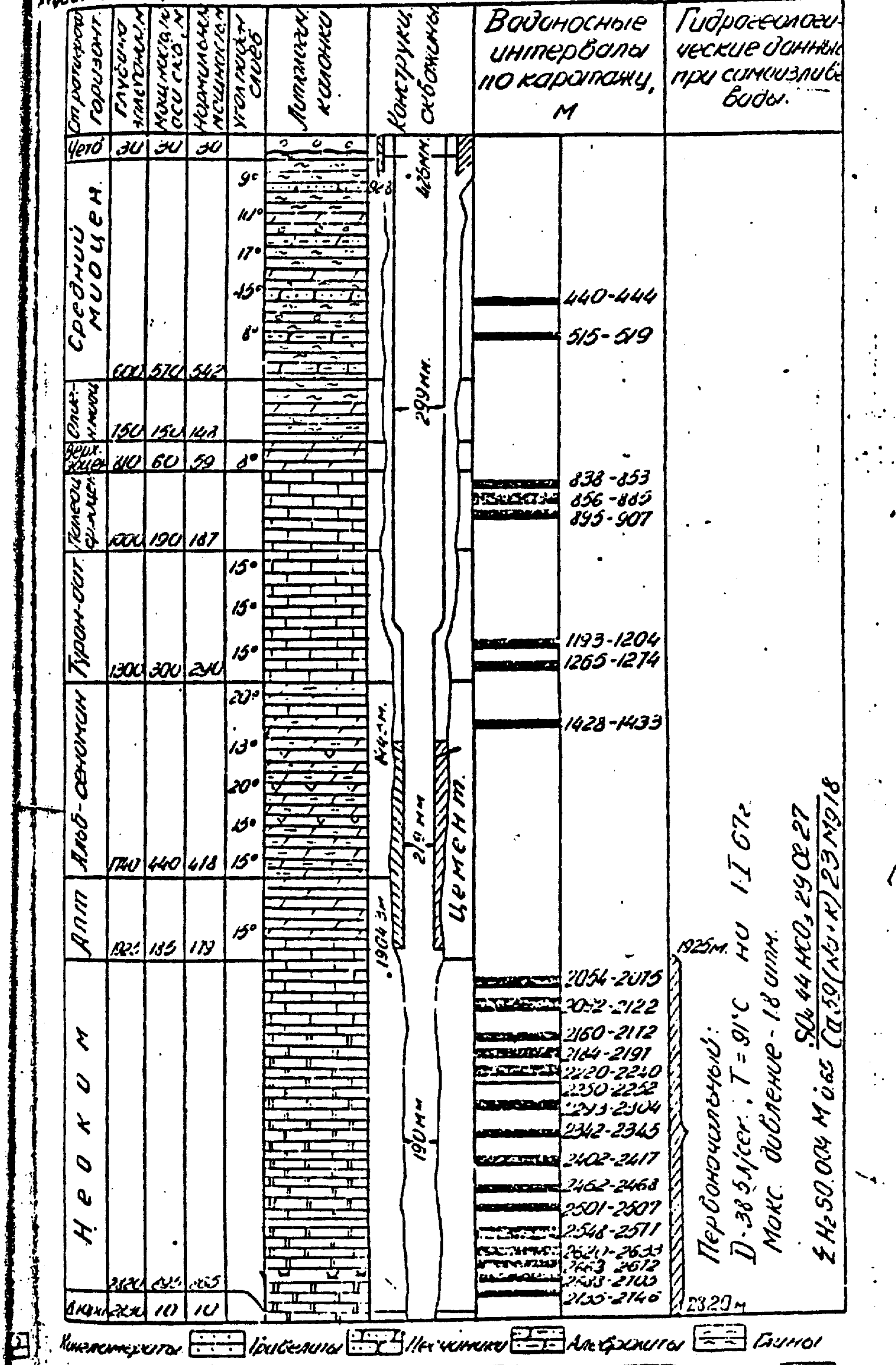

рис. 8

The observations made during 1983 showed, that the water debit for the year decreased from 2900 m^3/day to 2400 m^3/day, and pressure from 0, 175 Mpa (1,75atm) to 0,12 Mpa. At the same time, the temperature (84^{0}c) and the chemical composition of water didn't change. In January1984, the artesian flow from the well seaced and water level staid at 12 meters. For 1.08. 1984 the water level was on 12,0m.

Well section and design aregiven on the drawing 9.

Well N4 (Zugdidi) is drilled in 1968 at Zugdidi south part near the area of Inguri Paper combinate. Offing's absolute elevation is 96,3m. depth 2633m. The uncovered neocom deposits on the depth of 1224m.. At the end of the drilling works artesian flow was obtained in the amount of m^3/day, T - 72^{0}C. Maximum offing pressure was 0, 088 Mpa (33).

According to the chemical composition water was of chloride-hydrocarbonate-sulphate magnium- sodium-calcium type.

$$M_{1,0}\frac{SO_4 63\ HCO_3 19 Cl\ 18}{Ca\ 54\ Na\ 26\ Mg 19}$$

The following (1973) observations showed, the debit decrease to 1300m^3/day. Temperature and chemical composition remained unchanged.

In April 1975 the artesian flow from the well seaced and water level stopped on 12m below the well offing .

For provoking an artesian flow in September 1975 rehabilitation works were carried out. Artesian pump was drawn down into the well, with the help of it thermal water with 200-1460 m^3/day debit, temperature 71^{0}C was extracted. The well worked with such a debit till 24/III-1978. Afterwards flow ceased, the level fell little by little down to "-" 10 m.1/IX-1982 water level was on the mark 28.5 m below the earth level, later the level was fluctuating within the limits of 32-34 m.

Well section and design are given on the drawing 10.

Well No.3 (Tsaishi) was drilled in 1973, 40m from Tsaishi base well No.1-op. Absolute elevation of the offing is 34 m. Well depth 180 m. The well entered the neocom deposits within the limits of 730-1790 m, then entered into Alb-apt rocks and opened neocom deposits within the interval of 2122-2974 m (drawing 7). After the end of drilling within the interval of 598-845 m thermal water artesian flow was obtained, the debit made up 900 m^3/day, water temperature 79^{0}C.

In September 1974, with the aim of increasing debit, within the interval of 1195-1785 m perforation works were carried out, after which debit increased up to 2311 m^3/day, temperature 84^{0}C. The pressure on the offing 0.62 Mpa. Received water by chemical composition was of chloride-sulphate sodium-calcium type.

ГЕОЛОГО-ГИДРОГЕОЛОГИЧЕСКИЙ РАЗРЕЗ И КОНСТРУКЦИЯ

поисково-разведочной скважины №3 Зугдиди Н-93.3.м

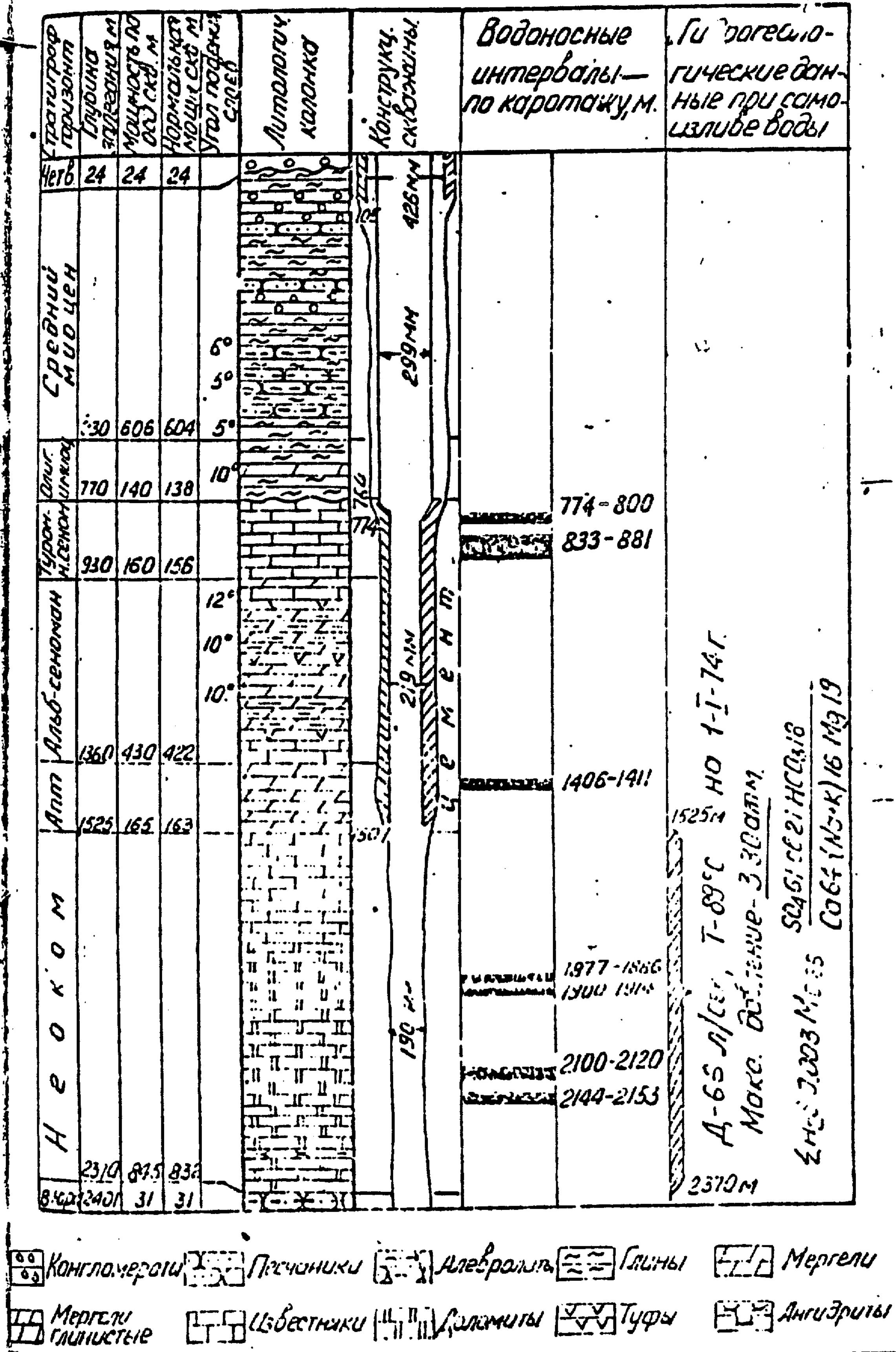

Рис. №9

ГЕОЛОГО-ГИДРОГЕОЛОГИЧЕСКИЙ РАЗРЕЗ И КОНСТРУКЦИЯ поисково-разведочной скважины №4

Зугдиди. Н-96,3м

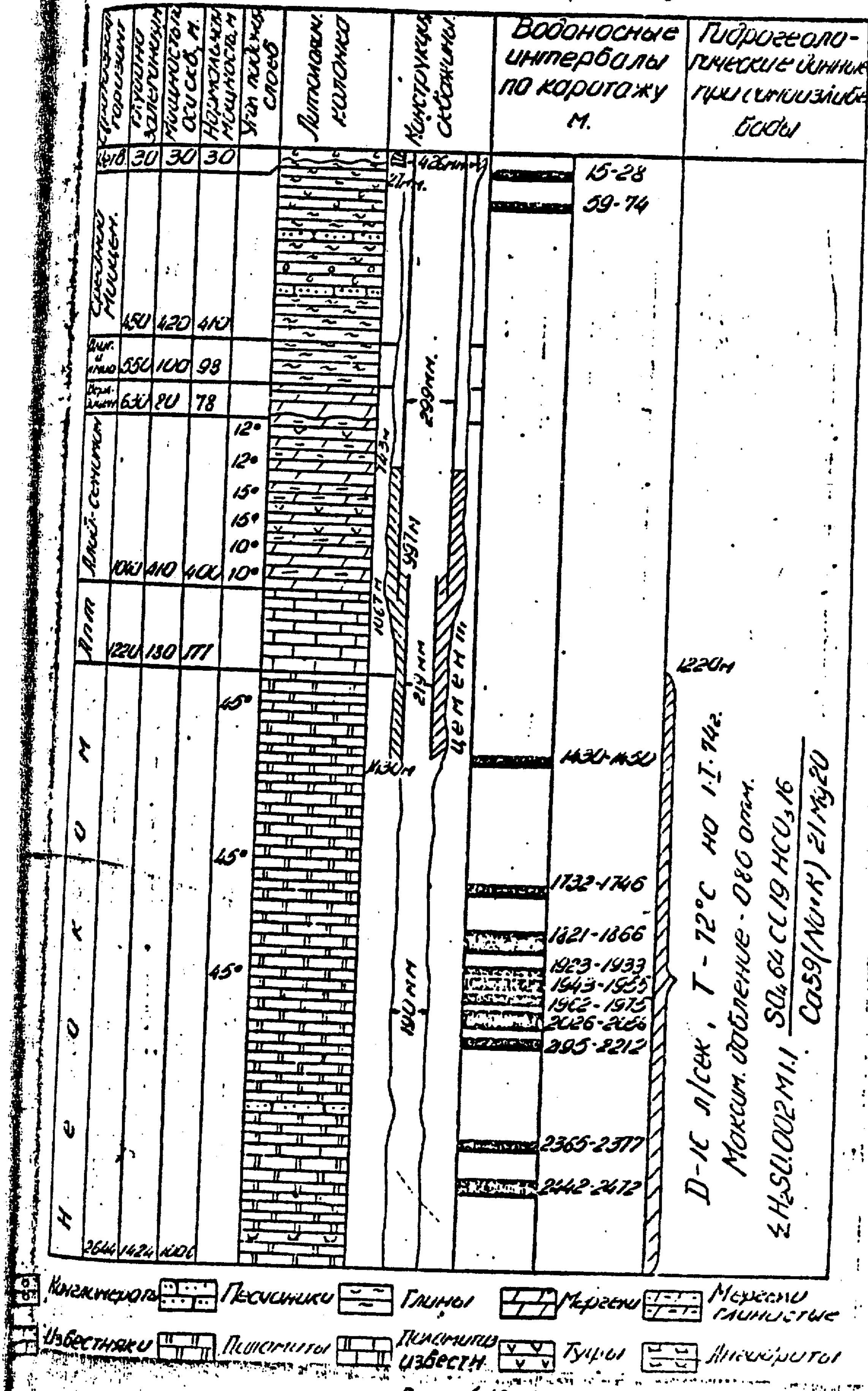

Рис. №1а

62

$$M_{1.7} \frac{SO_4 66\ Cl 24}{Ca55(Na+K)23}$$

The following observations were carried out in 1979-1980. Water debit made up 2000 m^3/day, temperature 84^0C, pressure 0.63 Mpa. For 1/VIII-1983 from the well was extracted the water of 2637 m^3/ day amount, T-82^0C, pressure 0.4 Mpa. The well became uncontrolled and had gryphons. After getting the thermal water industrial flow from well No.8-t, the well No.3 was liquidated.

Well No.1-t was drilled (1. 1980) on the left bank of r. Chkhoushi near Tsaishi. The offing absolute elevation is 50 m, depth - 1272 m. The well entered neocom deposits on the depth of 780 m. Neocom thickness along the well axis is 492 m. By chemical composition the water is of chloride-sulphate calcium-sodium type.

$$M_{1.68} \frac{SO_4 74\ Cl 19}{(Na+K)50Ca40}$$

Initial hydrogeological parameters of the well were the following: debit 5500 m^3/day, pressure 0.57 Mpa, temperature 87^0C.

The later measurements (24/X-1981) showed, that the water debit decreased down to 4485 m^3/day, temperature 87^0C, pressure 0.46 Mpa. For 1/IX-1983 debit made up 4075 m^3/day. For 1/IX-1984 water debit made up 3930 m^3/day, t - 86^0C, $P_{working}$ - 0.015, $P_{established}$ - 0.30 Mpa.

Well section and design are given on the drawing No.3.

Well No.2-t was drilled in 1980 near Tsaishi on the left bank of river Chkhoushi at the distance of 2.95 km to the North from the well No.1-t. Well offing's absolute elevation is 60 m. Depth 1904 m. The well injected neocom deposits within the interval of 1388-1904 ms. Thickness of these deposits is 510m (drawing 4).

After finishing of drilling the water debit made up 5000 m^3/day. Temperature 83 ^{0}C. Chemical composition of water is analogous to the water from the well No.1-t.

In the following period water debit decreased and fixed on 4100m^3/day, pressure made up 0,466 Mpa. Presently (I. IX. 1984) water debit of well No.2 makes up 3000 m^3 day, offing pressure 0,35 Mpa, T-87^0.

Well section and design is given on the dwg.No.4.

Well No.3-t was drilled in 1982. On the left bank of r.Dzhumi in Tsaishi and the north-east side of the well No.1-op at the distance of 1,4 km from the latter. The absolute elevation of the well offing is 71 m. Depth - 1991m. The well injected neocom deposits on the depth of 1098m and was drilled down to 1900 m. The water debit at the end of the drilling amounted 500m^3/day, water temperature 80^0C. Pressure on the well offing was 0.36 Mpa (19/vii-1983) For I/IX - 1984 water debit on the well offing 604 m^3/day, T-81^{0}C. For I/IX - 1984 water debit made up 500 m^3/day T-81^{0}C. Pestab - 0,10 Mpa

Well section and design is given on the dwg.No.5.

Well No.4-t was drilled on the lift bank of r. Kulis Kapi the well offing absolute elevation is 61 m. Depth 2527 m. Drilling is finished 14/III - 1982. By the well the following stratigraphic section is opened: Quaternary deposits (0.0-30m), clay deposits of middle Miocene period (30-745), maykop series clays (745-1120m), Chalk limes (1120-1620m), apt-Cenomanian clayish-marls (1620-2160m) and limes and and dolomites of Neocom (2160-2527m).

Well section and design are given on the dwg. No.6.

Artesian flow was not got from this well. On July 1, 1984 the testing and well operation started.. For 4 days (50 hours) by compressor UKP-80 from the well was extracted 500 m^3/day amount of water, with t-60^{0}C. After stopping of compressor water flow stopped and water lowered down to negative level. Thus, from the well No.4 thermal water artesian flow wasn't obtained.The water level in the well No.4-t during 1984 varied within the limits of -19-22m.

Well No5 was drilled on the right bank of the river Kulis-kari. Offing's absolute elevation is 72,7 m. Well depth 2661m. Drilling started at 20/X-1981 and finished 22/VIII-1982 (see dwg.No.7). The well drilled Plyocenian sandstone-clay deposits (0-395m), carbonate clays (395-800m), myocenian marls and sandstones (395-800m) light-gray shale clays with olygocenian fish scales and low miocenic (800-1190m), jointy dolomites, limes and breccia type limes of neocom (1190-1620m).

Artesian flow was not obtained at the well. At the end of July 1983, the flow of thermal water was provoked by compressor HKP-80. According to the measurements 2/VIII-1983 water debit made up 1500m^3/day, temperature 83^0, pressure 0,18Mpa. Soon after inflow, the artesian flow stopped.

The ceasing of artesian flow is probably caused by the full discharge of thermal water from all wells during winter period and water discharge from Tsaishi wells N3 and 8.

Well N6-t is drilled on the right bank of r. Choushi, absolute elevation of Well offing is 73. 8m, depth 2331m. Drilling is started at 22/XI-1982 and finished for 30/IV - 1983.

By the well the following stratigraphic sections are opened: 0, 0-60m of Quaternary deposits, 60-370m of Plyocenic sandstone-clay deposits, 370-570m light-grey layered clays with fish-scales of Mycop suite, 570-1210m of marl, sandstone and tuffbrecia Alb-Cenomanian alternations, 1210-2331m of dolomitized limes and neocom limes (drawing 8). The well didn't give artesian flow of thermal water. Water level fixed on 12-15m. In order to preserve dynamic balance of the deposit and to carry out observations over the water level variation, water inflow was not artificially provoked and the well was converted into the observation well.

Well N8-t was drilled on the right bank of r.Dzhumi on the offing's absolute elevation 28,90 with the depth of 1675m. Drilling started 29/V-1983 and finished 28/VIII - 1983. By the well is uncovered the stratigraphic section: 0-40-Chalkck, 40-550m alb-cenomanian, 550-730m-apt, 730-1800m-neocom (drawing 9).

In drilling process from the depth of 780m(15/VII -) the outflow of thermal water was obtained , which after reaching actual tamp on 1675m amounted 5500m^3/day debit with the temperature at outflow point - 83^0 C. Later observations showed debit increase, which stabilized time by time, and made up 7200 m^3/day with t-84^0 at outflow.

From 1/I-1984 up to 1/VII - well debit varied within the limits 1950-6100 m^3/day. For 1/X - 1984 the well gave water of 1000m^3/day amount, with t - 84^0 C.

Chalk - paleocenian clay- carbonate deposits are exposed to the surface along the north-east frame of megrelian basin and the center of Urtine (Tsaishi) anticline near Tsaishi. Exposures of paleocenian and. Chalk deposits on Urtine anticline are characterised by erodness and carstyness. Upper waterproof of waterbearing complex are Chalk marls and covering clays of Maykop suite. The complex is underlayed by the waterproof apt-Cenomanian marl-clay formations.

Total thickness of Paleocen-Chalk waterbearing complex amounts 450 m.

According to conditions of circulation of underground water in Tsaishi deposit area, the zones of crack - carsrtic water with the distinctive (original) surfaces are marked out. In the zone of active water exchange cold, fresh water of hydrocarbonate-calcium composition are present. Total mineralization of this water makes up 0.4-0.6 g/l, temperature 14-17^{0}C. This water is turned into springs, which come out at the lower parts of landscape. There also must be some hidden places of water discharge along the valley of r. Dzhumi.

To the zone of delayed water exchange Paleocene-Chalk complex belonged the uprising sulphide mineral waters. Presently this water is revealed by prospecting drilling wells (34).

The total maximum outlay of all sources made up 80 m^3/day. By chemical composition the water was of hydrocarbonate-chloride-calcium-sodium type. Mineralization 2.7 g/l. Total nitrated sulphur 12 mg/l.Temperature 17-27^{0}C, P_H 7.4. Sulphide water, extracted by wells, are analogous to the spring water. However, hydrogene sulphide in it and water temperature are a bit higher, than in spring water. As a result of prospecting works, carried out by "Gruzgeokaptazhminvod" (1972-1973) on Tsaishi deposit of sulphide water by wells No. 5,7,9 from the depth 200-500 m from paleocenian Chalk deposits was opened subthermal sulphide chloride-sodium water with mineralization 2.5-2.8 g/l. In some wells (No.2, 12) minor inflow of sulphide chloride-sodium water with total mineralization 12-13 g/l (34) has been obtained

According to the researchers' opinion, such a sharp change of total mineralization in paleocen Chalk deposits is caused by the fact, that the water obtained by wells No.2. 12 is formed in hydrogeologically more isolated parts of the structure.

The revealed reserves of Chalk-paleocenian complex of sulphide water are approved by GKZ in 1979 in amount of 80 m^3/day by B category, and of 120 m^3/day by C (record No. 8269 of 18 April 1979).

5.3 Result of water test injection into a productive stratum

In order to determine the neocom waterbearing horizon's capacity at different pressure the test water injection into productive stratum of Tsaishi wells No. 2-t and 5-t was carried out. Into well No. 5-t the river water (see table 11)was injected, while into the well No. 2-t the thermal water (86^0) from the well No. 3 Zugdidi.

Injecting into the stratum or well No. 5-t was carried out at three regimes by 4 cementing aggregates (see drawing 11). On the regime 1 the cemented aggregate with 15 l/sec output raised the pressure at the beginning of injection up to 50 atm. which was gradually falling and in 30 minutes fell down to 25 atm. With such a pressure injection into stratum was going on during 2 hours. During this time with unchanged pressure, water of 110 m^3 was injected stratum into, e. i. stratum accepts the water with 15.27 l/sec rate, and - 1322 m^3 if turned into days. Later the injection at regime II with two cementing aggregates with 31 l/sec capacity was carried out. While injecting, at the beginning the pressure raised up to 40 atm, which was gradually falling and in 11 minutes it fell down to 31 atm and in 40 minutes down to 27 atm. At such a pressure during 2 hours 225 m^3 of water was injected into stratum, e.i. at such regime stratum can get 31.3 l/sec amount of water, which turned into days is 2704.3 m^3.

Water injection into stratum at the regime III was carried out by three cementing aggregates with 45 l/sec output. During the injection process the pressure raised up to 50 atm. After some minutes pressure fell down to 40 atm. At such pressure during 20 minutes into stratum was injected 54 m^3. So neocom limes get water with 45 l/sec velocity, e.i. turned into days 3,888,000 l/day - 3888 m^3/day.

In the next experiment Zugdidi well No.3 water with temperature 86^0C was injected into the well No.2-t Tsaishi. Water was pumped at the pressure of 10 atm.

At the beginning well No.2-t at such regime could accept an amount of 1728 m^3/day, but after 12, 30 hours, the well could get water in amount of 1200 m^3/day, and pressure in well increased up to 7.7 atm. During several days the the water acceptance of the well No.2 did not change. Thus, the experiment showed, that at pressure from 10 atm to 40 atm neocom waterbearing horizon's acceptance of water through one well varied from 1200 to 4000 m^3/day (see draw. II 12). Besides, it must be admitted, that at back pumping into the water stratum of the same horizon, water quality of the production thick must not change.

Chemical analysis of the river water injected into the well No.5

July 1983 Table II

	mg/l	mg/equiv.	equiv.	Note
NH_4	1.48	0.08	0.03	
Na+K	20.27	0.81	27.1	
Mg	8.6	0.71	23.5	
Ca	30.0	1.50	50.0	
		3.02	100.63	
Cl	5.7	0.16	6.04	
SO_4	49.0	1.02	34.2	
HCO_3	98.8	1.60	60.1	
NO_2	0.020	-	-	
NO_3	2.21	0.04		
		3.02	100.34	

$$M_{0.225} \frac{HCO_3\,67\,SO_4\,34\,Cl\,6}{Ca50(Na+K)27Mg23}$$

6. WATER QUALITY CHARACTERISTICS

Zugdidi-Tsaishi deposit thermal water is of low mineralization, chloride-sulphide sodium-calcium.

General mineralization of water from certain deposits is within 0.6 g/l-1.7 g/l. Mineralization value decrease and of certain ions takes place from the South to the North, i.e. from Tsaishi to Zugdidi direction. Particularly, general mineralization of the extreme south well of the deposit, Tsaishi No 4-K in certain cases reaches 1.7 g/l and decreases down to 0.6 g/l in the north well water, Zugdidi No 1 (which is not operating at present). Correspondingly, certain ion amount decreases also: chlorine from 312 mg/l to 67 mg/l, sulphate from 816 mg/l to 158 mg/l, calcium from 280 mg/l to 24 mg/l, sodium from 240 mg/l to 40 mg/l , etc.

General mineralization and its components decrease from North to South coincides with total underground water flow direction of neocom deposits from the feeding area (southern Caucasian chain) to the discharge area, which explains such changes of chemical composition of water on the area. Despite the above-mentioned difference in mineralization, separate ion ratio does not change and chemical composition formula of deposit waters seems the same. (Tables 12,13).

Chemical composition of the deposit waters is rather stable, according to continuos observations and in fact, does not change in time. Among the anions, sulphate ion is leading. Percentage of sulphate composition in thermal waters of various wells is within 52-73% (from Zugdidi to Tsaishi direction).

The second in all test results is chlorine ion, percentage composition of which in various wells changes from 17 to 36%. Last of all is ion hydro carbonate.

In cation composition of all wells without exception first is ion calcium (46-58%) . Then comes ion sodium (19-41%) and last of all is magnesium (13-22%). There is SiO_2 in great quantities. In various wells of Zugdidi-Tsaishi deposit it is in amount of 57-77 mg/l (Table 14).

During thermal water discharge there is no gas phase spontaneous emission. There is hydrogen sulphide scent. In the solved gas composition there is carbon acid in amount of 13-43mg/l and hydrogen sulphide 3.9-8.2 mg/l. The leading is nitrogen of 56-83%. There is insignificant amount of methane (0.9-2.9%). Increase in quantity of CO_2 and H_2S takes place from the North-east (Zugdidi well) to the south-west direction (Tsaishi well). Gas composition is not high in water and amounts to 20-24 cm^2/l (Table 15).

Zugdidi-Tsaishi deposit waters contain light phenols in various amounts 4-25 (Table 14). Bacteriological researches of waters showed that the water is not infected and contains total amount of bacteria less that 100 in 1ml, and coli-titr indicator is more that 300 (according to State standards 8963-73) (Appendix 4). In Table 16 there is given chemical composition comparison of Zugdidi-Tsaishi deposit with State Standards 2874-82, "Drinking Water".

- geothermal water flow speed influences on metal corrosion speed;
- geothermal water pH increase above neutral value results in significant suppression of corrosion processes;
- geothermal water nutrition by air oxygen with simultaneous partial removal of sulphur hydrogen and carbon acid increases construction metal corrosion 3-10 times more. Corrosion character gets erosive, which is typical for oxygen corrosion;
- speed of metal corrosion caused by idle operation of industrial thermal energy equipment of geothermal systems in heat utilising is higher than its speed in natural waters;
- anti-corrosion affect in geothermal heat utilisation could be gained as follows:
a) vacuum degasation of geothermal waters of any chemical composition aiming at spontaneously emitted, also corrosion aggressive solved gases removal without air oxygen access to air oxygen water;
b) by regular dozing of the silicate sodium mixture with calcium chromate capable to passivate metal;
c) by regular dozing of the substances increasing pH of geothermal waters;
d) by using double network diagram with intermediate heat exchangers;
- technical and economic comparison of the geothermal heat utilisation diagrams with above mentioned method application in metal corrosion decrease show that at low thermal loading of the system, in fact all methods have equal economical efficiency. With thermal loading increase the significant advantage is given to vacuum degasation of thermal waters.

Since 1951 there had been carried out a number of chemical tests of Zugdidi-Tsaishi deposit. Standard analyses were carried out in the Central Laboratory of the Department of Geology of Georgia. Full analyses were made in hydrochemical laboratory of the Hydrogeology and Engineering geology of Georgian Academy of Sciences. Gas analyses were made in natural gas department of the same department.

Control analyses were made in hydrogeological Resort Researches Institute laboratory.

6.1. Zugdidi-Tsaishi Deposit Thermal Water Generation Problems

In Georgian Clod area there are developed artesian horizons with nitrogen, methane and sulphur hydrogen waters of various chemical composition from weak mineralisation hydrocarbonate calcium to high mineralization of chloride calcium salt water (12).

On the territory of Georgia there is total vertical hydrodynamic and hydrochemical zoning typical for folded structures. For instance, by underground water circulation intensity there could be picked following hydrodynamic zones:

1. Upper zone of active water exchange;
2. Zone of slow water exchange;
3. Stagnant zone of water rate or of very slow water exchange.

The following hydrochemical zoning refer to the marked hydrochemical zoning: under fresh hydrocarbonate calcium magnesium waters there are developed hydrocarbonate sulphate and below it sulphate or sulphate-chloride waters. Then there are chloride sodium and under them sulphate-chloride waters. Water rate changes in depth are accompanied by gradual water mineralization rise from gram portion up to some hundred grams per litre (12). In mountain folded areas of heterogenic construction typical representative of which is Georgia, there are sites of ground with azoning, i.e. above mentioned normal zoning distortions (inversion).

Standard example for such azoning of the region is central Megrelian synclinal (in Mengrelian artesian basin), consisting also of Tsaishi deposit thermal waters.

Tsaishi deposit has following characteristics: in the area of active water exchange (in all deposits opened on the surfaces) there circulates fresh water of 0.5 g/l mineralization (see description of water bearing horizons). below in the area of slow water exchange there is located water bearing horizon of upper chalk-paleogen. containing high mineralised sulphur hydrogen chloride sodium waters. For instance. in well No 12 drilled by the Department "Gruzgecaptazhminvod" in 1974 with the intervals of 268-393 m from the rocks of upper chalk there was extracted water of the following composition:

$$H_2S_{18}M_{12}\,\frac{Cl95Hco_35}{Na\ 96Ca\ 2}$$

Lower this area there are located water bearing horizon of neocom lime of 1100 m capacity containing nitrogen chloride-sulphate and sulphate weak mineralization waters. For instance, from Zugdidi well No 3 from the horizon of lower chalk with 3000 m^3/day and night there came water of the following composition:

$$M_{0.98}\,\frac{SO_445Cl39HCO_316}{Ca46Mg27Na23}$$

Under this horizon there is stagnant water rate area of very slow water exchange capacity. Particularly, eruptive-sediment deposits located under neocom lime bios contain high mineralization waters and salt waters of chloride-calcium type. Typical representative of such waters are popular medicinal waters of Lugela discharged on the North board of the Mengrelian synclinal the composition of which is as follows:

$$M_{52}\,\frac{Cl\ 99}{Ca\ 87}$$

This made the explorers (Buachidze, 1958) to additionally separate one specific mountain-folded areas of "low area of active water exchange" under the slow water exchange.

Thus, as was shown above, hydrochemical zoning of underground waters somehow is depended on hydrodynamic zoning and reveals the deviation from general scheme.

The reasons causing such inversion of zoning are worth paying attention to, i.e. those which cause rather intensive circulation in more deeply sunk horizons of low chalk. The conditions of low chalk horizon of underground water formation should be viewed which will make the reasons for existing azoning on area-under-consideration clear.

Large capacity of the horizon, intensive karsting on the surface, as well as in depth, penetrating ability of cracks and hollow karst sites, abundance of atmospheric precipitation in the feeding area cause high water abundance of the whole site.

Well arranged underground water circulation ways in these rocks prove of high debits (up to 100 l/sec) of gushing waters, strong leakage of flushing solution during drilling, fall-through after drilling device operation down to several meters deep, solubility and discharge of great amount of substances by acid thermal waters. All these prove of significant development of hydrothermal karst in these deposits (9). Intensive underground water circulation in neocom water bearing horizons result in abundance of atmospheric precipitation in the feeding area and also in big difference between feeding and discharge areas (or water extraction mark from the wells). As is known, surface water leakage in carbonate deposits of neocom takes place on the slopes of southern spurs of the Big Caucasus on 2000-25000 m marks and discharge takes place in the Black Sea water area as subaqual springs. Besides, in the wells water is extracted from neocom at the depth of 2500-3000 m below sea level. Thus, the difference between the feeding and discharge levels is 5000-5500 m which causes intensive circulation and strong head of underground waters in neocom water bearing horizons and as a consequence, horizon flush from chloride waters of stagnant flow rate. During underground water leaking at great depths of the Mengrelian synclinal, underground water temperature reaches the level corresponding to geothermal grading of the area (see geothermal conditions). As was noted, in Tsaishi deposit there was found most abnormal temperature: 72^0C at the depth of 650 m. In temperature field formation of the region convective heat transfer is thought (Buachidze) to have the main part (3).

Let's view chemical gas composition of thermal waters of low chalk water bearing horizons. These waters have low mineralization (0.6-1.7 g/l) atmogenic nitrogen and sulphur hydrogen scent (up to 8.2 mg/l). In anion composition the leading are sulphate and chlorine ions and in cations the main are calcium ions, sodium and magnesium.

Low mineralization of waters could be explained by intensive flushing of the rocks due to favorable conditions of discharge in the Black Sea water area which was to start from pleistocene? (12).

Principal scheme of such water formation in upper hydrogenous area is well studied and worked out (Posokhov, 1968, 1975, Kolotov, Rubeikin, 1970, Shvartsev, 1978, 1979 et al), that's why it is not difficult to draw the ways of its formation. We should only note, that in the given case, we mean low chalk water bearing horizon, despite great depths, there also is similar area of hypergenes of geochemical environment (intensified circulation, air gas supply, oxidizing environment, etc.). Tsaishi water formation process can be given by the following scheme: surface waters except salt have great amount of solved gas (nitrogen, oxygen, carbon acids, inert gases, etc.), which penetrating together with water in mountain rocks significantly define underground atmosphere shape (29). Chemically active O_2 and CO_2 seized by surface waters in feeding area participate in various reactions and relatively inert nitrogen gradually concentrates in water. By inert gas and isotope composition of oxygen ratio there is set unconditional atmogen?, also current age of gas-water system (37).

Interaction of water and initial aluminosilicate leads to pH>7 alkalinity formation where alkalinity neutralisation by means of carbon acid does not take place and sulphur hydrogen by oxidising of sulphide minerals.

Depending on geothermal step of the site, on surface water saturation depth and also on way length to discharge site, thermal waters of various temperature flow on the surface. Chemical composition and general mineralization of these waters mainly depend on lythology of containing rocks, also on intensity of water exchange and duration of water-rock interrelation which defines extent of underground water concentration atmogenic, biogenic and lythogenic elements. Particularly, Tsaishi deposit is enriched by ion sulphate, hydrocarbonate, calcium and magnesium through alkalinity water purifying carbonate rocks (as was indicated, water bearing horizon is represented by lime and dolomites, anhydrite interlayers in geological part of low chalk). This is proved by analysis result of low chalk carbonate rock water extraction (28).

Water extraction of carbonate rocks were performed at rock ratio: water - 1:5. Below we give chemical composition formula of water extraction carbonate flysch of upper jura and low chalk age, terrigenic flysch of low chalk and lime thickness of upper chalk from various regions of Georgia.

Carbonate flysch
(Average of 32 analyses)

$$\frac{HCO_3 53\ SO_4 36\ CO_3 8 Cl3}{Ca87Mg6Na3K2Fe2}$$

Terrigenic flysch K_I
(Average of 9 analyses)

$$\frac{HCO_3 70\ SO_4 24\ CO_3 5 Cl1}{Ca54Na18Mg16K12}$$

Lime thickness K_2
(Average of 4 analysis)

$$\frac{HCO_3 65\ SO_4 35}{Na53Ca33Mg8K6}$$

Problems connected with chlorine and sodium genesis seems rather complicated.

As water extraction analyses of carbonate rocks prove, the latter cannot be deliverers of underground water chlorine, more of low chalk horizon waters, where chlorine reaches 355 mg/l (well No 1-op). Analysis of general hydrogeological conditions of the region and Tsaishi site itself make us come to the following assumptions: chloride waters directed in underground waters of low horizon is supplied from low bedding water bearing horizon of bios porphyrite suite along the Urtine fracture. as it was noted above, high mineralization chloride calcium water is typical for bios eruptive-sediment thickness (up to 50-340 g/l) Lugela, Gumarishi, Tskhunkuri, Ochamchire). Besides, tectonic fracture cutting the rocks forming Tsaishi deposit of thermal waters cause so-called "Tsaishi geothermal abnormality" through convective transfer of deep heat. Above mentioned factors confirm our assumption more by conversion of ion composition of Tsaishi waters to salt ones showing alkali ground chloride contents. as for sodium, it may be converted to underground waters from water containing ones, which is proved by analysis result of water extraction of these rocks. Sodium partially can be extracted from the depth together with chlorine.

7. Results of Hydrodynamic Research at Zugdidi-Tsaishi Area

7.1 Methods of Test Data Processing

For data processing used to determine hydrodynamic parameters of water-carring seam, the most convenient are graphical-analitical methods of establishing the level in time and area (Jacob methods), which are used during quasistationary filtration regime.

Graphical-analitical methods of determining the parameters are based on the analysis of direct dependencies between the decrease of level and time or distance. In an unlimited, homogenous, grain,water-carring seam, the only factor that causes deformation of direct regularity of level changes in time and area, are technical conditions of tests. In this case the classic version of Jacob Method is most applicable. Test data processing is carried out based on logarithm approximation of Tais equation:

$$S = \frac{0,183\,Q}{K_m} \lg \frac{2,25\,at}{r^2} \qquad (1)$$

In order to determine the dependence used for calculating parameters, the equation given above is written as an equation of a line in half-logarithmic coordinates: decrease (ordinate axis) relative to time logarithm lg t, distance lg r and complex factor lg t/r^2.

Calculated parameters - water conductivity coefficient K_m and piezo-conductivity a - are determined from angular coefficients C and starting ordinate A of diagrams mentioned above.

Stability of outflow debit Q is one of the necessary conditions of using Tais-Jacob equation. When outflow debit changes, as it was observed during the tests at Zugdidi-Tsaishi area, decrease in observation wells is approximated by means of equation similar to (1), which can be written as a straight line relative to the decrease (S/Q) in coordinates:

$$\frac{S}{Q} = A_t + C_t \lg t \; ; \quad \frac{S}{Q} = A_r - C_r \lg r \; ; \quad \frac{S}{Q} = A_k + C_k \lg \frac{t}{r^2}$$

Water conductivity and piezo-conductivity coefficients are calculated by the following formula:

1. Method of time observation

$$\frac{S}{Q} = \lg t \; ; \quad K_m = \frac{0,183}{C_t} \; ; \quad \lg a = 2 \lg r - 0,35 + \frac{A_t}{C_t} \qquad (2)$$

2. Method of area observation

$$\frac{S}{Q} = \lg r; \quad K_m = \frac{0{,}366}{C_r}; \quad \lg a = \frac{2\,A_r}{C_r} - 0{,}35 - \lg t \qquad (3)$$

3. Method of combined observation

$$\frac{S}{Q} = \lg \frac{t}{r^2}; \quad K_m = \frac{0{,}183}{C_m}; \quad \lg a = \frac{A_k}{C_k} - 0{,}35 \qquad (4)$$

During the outflow there was debit change in disturbance well, and the regularity of this change is stright line in coordinates 1/Q - lg t.

As a result of different well disturbances, value 1/Q is higher than it should be. That's why it's impossible to get piezo-conductivity coefficient in disturbance wells. Water conductivity coefficient is determined by means of equation:

$$K_m = \frac{0{,}183}{C^5O} \qquad SO = \frac{\sum SO}{n}$$

The above described method and formulas for defining hydrodynamic parameters are used in case of homogeneous grain, water carring seam. At Zugdidi-Tsaishi area the explored water-carring Neocom seam is represented by cracked carbonate oils, which as a rule have very unhomogeneous and unisotropic filtration and hygroscopical features.

The main questions of unstationary filtration in cracked - porous medium were worked out by Barrenblat and Zheltov (1). They showed, that as the time passes, the solution of problem of water filtration in cracked-porous medium asymptotically coincides with the solution for usual porous medium. That's why if the time of the considered processes is big enough compared to the time of delay of transition processes (time of liquid exchange between porous rock and cracks that divide them), then, for calculations, usual Tais-Jacob equation of filtration in porous medium can be used. The mentioned equations are valid also for cracked rocks.

In cracked rocks, asymptotical areas of tested regularities of level changes, which can be approximated by means of Tais-Jacobs equations, are formed with a little delay in comparison with usual grain seams. Time of delay, when asymptotics is reached in diagrams, changes in a wide range and is practically unpredictable. Approximate time of delay taken from actual time diagrams in testing of cracked and cracked-karst horisons in specific areas change in a wide range from several to 300-400 hours (30).

Choice of calculation areas of time and combined diagrams is carried out based on qualitative analysis of test regularities of level measuring in outflow process.

7.2 Processing of hydrodinamic research results

In the period from July to October, 1981, Hydrological research was carried out in Zugdidi-Tsaishi area. The aim of this research was to determine filtration - capacity parameters of apt-neocom thermal-water-carring seam.

Hydrogeological research was based on pumping out and well No.1-Tsaishi was taken as the main one, that operated with the initial debit 5000 m^3/day. Observation wells were No. 2-t Tsaishi, 3-t Tsaishi, 3-Zugdidi where well head pressures were measured. In wells 1-Zugdidi, 4-Zugdidi, 4-Tsaishi underground water levels were measured.

Before the area research, well head pressure, underground water level and debit for operating wells were measured in order to determine stabilization regime of deposit.

Hydrodynamical research was carried out in two stages. At the first stage observation of level and head changes in time at observation wells was carried out with outflow of thermal water from well No.1-t. At the second stage - with joint operation of wells No. 1-t and 2-t.

At calculating filtration parameters of Apt-Neocome lime, different experimentap data of the first stage were used as several measurements carried out during group outflow from wells No. 1-t and 2-t are not enough for graphic analytical method of data processing.

Time diagrams for perturbation and observation wells were drawn in coordinates Q-t, 1/Q - lg t, S/Q - t, S/Q - lg t (Fig. 7.3 - 7.10). On curves of S/Q - lg t for wells No. 1-t, 2-t and 3-t there are two stright line sections, that make it difficult to distinguish asymptotic sections. This form of curves is explained by the complicated geologic structure of the studied area. Tectonic disturbance that cuts the Tsaishi anticline arch and the cracked type of the collector requires special accuracy at diagnosting diagrams S/Q - lg t. In this case on one hand it is`necessary to carry out long tests in order to exclude the influence of microhomogenuity, while on the other hand, in case of long tests, influence of dorders (tectonic breaks) located near and deforming the shape of curves is revealed. In such conditions the most convenient form of data processing is combined diagrams S/Q - lg t/r^2 (Fig. 7.1). They help to analyze the confidence level of the obtained data and interpret time and area diagrams.

Experimental data processed by a combined method are given on combined diagrams S/Q - lg t/r^2 (Fig. 7.1). Usually the main part of the diagram S/Q - lg t/r^2 is asymptotic half logarithm straight line common for all observation wells. At Tsaishi area it coincides with the curve that is the farthest from discontinuity of well No. 1-Zugdidi, while the ending parts of the curves for wells No. 4-Zugdidi and 4-Tsaishi only are part of it. Diagrams of wells No. 2-t and 3-t at the starting stage also have this straight asymptotic line behaviour and then abruptly go up, that can be explained by the influence of an impermeable border (tectonic discontinuity). Coincidence of curves for wells No. 4-Tsaishi, which is located within the discontinuity area is determined by a high degree of crackness (rock grinding zone), that compensates the screen influence. Calculation parameters of combined observation are determined according to the angular coefficient (C) and starting ordinate (A) of the general asymptotic straight line, which is acceptable for well No. 1-Zugdidi, 4-Zugdidi, 4-Tsaishi during the whole observation period and for wells No. 2-t and 3-t until the moment of the begining of border factors. Water conductivity and piezo-conductivity coefficients, calculated from equation (4), are correspondingly 570 and $0.55x10^5$ m^2/day. Combined diagrams S/Q - lg t/r^2 of wells No. 2-t and 3-t start to deviate at decrease values $4.54x10^{-4}$ (t=264 hours) and $3.78x10^{-4}$ (t=93 hours). Hence, it means that the minimum time, during which at wells No. 2-t and 3-t border influence does not exist equals correspondingly to 264 and 93 hours. It is necessary to take into consideration in choosing calculation areas in time diagrams and using the data for those wells for area data processing.

Water conductivity coefficient K_m and piezo-conductivity a in time diagrams S/Q -lg t of observation well were defined according to equations (2) and change in intervals 376-915 m^2/day and $0,66x10^5$ m^2/day, that proves the anizotropic collecting properties of the water carrying seam.

Water conductivity coefficient calculated for perturbation well 1-t from time diagrams S/Q - lg t and 1/Q - lg t using equation (2.5) are equal to 457 and 508 m^2/day. Piezo-conductivity coefficient for well No. 1-t was not determined becouse this well is perturbation well.

Area tracing diagrams, built for 46, 93 and 192 hour time intervals are represented by straight, nearly parallel lines (Fig. 7.2). Only one item is distinguished from the general picture of the described decrease in well No. 3-t for 192 hours, that proves the influence of inpermible border in case of increase of minimum time of 93 hour for this well. Calculation of parameters was performed for two time intervals 46 and 93 hours according to formulae (3) and equals K_m= 563 and 572 m^2/day, a=0.21-$0.23x10^5$ m^2/day. Filtration parameters calculated by different methods are given in the following table:

Not determined position, configuration and character of borders does not permit to make a scheme of geologic structure of Tsaishi area for the existing typical schemes of thermal water operational resource calculations (44). In these complicated conditions estimation of thermal water resources are carried out by means of hydraulic methods, while data for forecast estimation are received during long operation - test discharge by means of measuring change of head in time.

The above mentioned facts suggest that in order to make a realistic estimate of operational resources of Zugdidi-Tsaishi deposit long term operation tests are necessary for productive wells in relation with a definite net of operational wells.

8. CALCULATION OF OPERATING RESERVES OF THERMAL WATERS

Operating reserves of Zugdidi-Tsaishi deposit thermal waters by category A+B in amount of 9078 m^3/day and C_1-18575 m^3/day have been approved in GKZ of former-USSR (Minutes N0 7384 of 29.04.1975) in 1975, this includes Zugdidi thermal water intake by category A-7128 m^3/day, by category C_1-17069 m^3/day, and Tsaishi deposit by 1850 m^3/day (categories A+B) and 1506 m^3/day (category C_1).

Geological exploration works with preliminary exploration were carried out from 1979 to 1984 approved by industrial enterprise "Soyuzburgas" to convert the reserves of category C_1 into higher ones. Preliminary exploration envisaged drilling of 6 wells and their construction was finished in the first quarter of 1984.

By hydrodynamics researches carried out at the preliminary stage of exploration, there interrelation Tsaishi-Zugdidi water intake was determined, which represent a unified system bordered from the south by tectonic distortions (Tskhalaia-Tsaishi fracture).

The studies have revealed significant heterogeneity of collecting qualities of apt-neocom thermal water bearing system, which was reflected in hydrodynamic layer parameter changes; the water conductivity coefficient varies within the range of 376-915 m^2/day, and piezo conductivity is 0.21-2.29x10^5 m^2/day. This is proved by drilling results. Wells No 1-t, 8-T, drilled at near arch area of anticline structure are characterised by debits (discharge) up to 6,000 m^3/day in comparison with well No 3-t, drilled in the syncline part and having debit up to 600 m^3/day.

Long-term operation regimes analysis (chapter 3) shows that the installation of a new well, as a rule, causes significant discharge decrease or self-pour-out ceasing at the operating wells (well No 3, 4 in Zugdidi), irrespective to the distance between them. Wells No 1-a and 4-k (I) are exceptions drilled at fracture site not sensible to long-term significant changes of water intake generally at the deposit (Drawing No 5).

Obviously, this circumstance is related with the presence of distortions around Zugdidi-Tskhakaia fracture which caused in its turn hydrodynamic separation of the operating wells' No 1-a and 4-k (1) location area, in the.

Geological and exploration works and regular observations of the wells located in the fracture area following them, indicate that these deposits promise to be very productive. Basic factor defining high discharge ability of the wells (No 1-t, 8-t), absence of essential interrelation between them (wells No 1-op, 1-t, 8-t) is their location at the arched, most cracked part of Tsaishi linear structure, their linear location in regards with the given structure, also relatively same absolute grades of the well heads.

Not less important and, perhaps, dominating is the factor presence of tectonic distortion parallel to the front of regional underground water motion of neocom complex. Tectonic distortions with the eruption amplitude of 1500 m resulted in natural screening on the way of regional motion of underground waters and, obviously, has changed regional direction of underground water motion in near to arch part of Tsaishi anticlyne structure along the fracture in the direction of the Black Sea. This situation together with the high crackedness of the near to arch part of Tsaishi anticline has caused the high abundance of drilled wells at this site (No 8) and their stable discharge (No 1-op, 1-a, 4-k). It should be noted that the relatively high discharge of the well No 8-t in comparison with well No-1-op, 1-a and 4-k discharge is related with its perfect design. If in the well No 8-t neocom complex is fully uncovered and is not lined, in the rest of the wells (No 1-op) it is covered II'' by a column with full cementing of the space behind pipes which later was injected or partially explored capacity up to 200 m of water bearing horizon (wells No 1-op and 4-k).

Existing geologic-tectonic, and also hydrogeological conditions of Zugdidi-Tsaishi deposit. the significant karsting and heterogeneity of collecting features and kartsing of the water bearing horizon complex along the distribution area enabled to attribute the given deposits to the second group.

The results of geologic exploration and hydrodynamic researches following them prove impossibility of operating reserve estimation by hydrodynamic methods, therefore, the evaluation of the reserves was based on long-term operation analyses and on regular observation results within the period 1983-1984 through hydraulic methods.

Long-term operation analysis (drawing No 4) is compiled based on scheduled observations' results obtained from all existing geothermal wells of Zugdidi-Tsaishi deposit within 1981-1984, i.e. from the date when the new geothermal wells had been put into operation. The analysis did not include the wells No 1-a and 4-k of "Tsaishi", resort and later they were also disregarded due to their permanent discharge ever after their installation.

It should be noted, that thermal water till 1982 was supplied to the consumers through two pumping stations constructed on wells No 1-op, 4 and 3 in Zugdidi with 2.520 and 4320 m^3/day capacity, respectively. In 1982 due to sharp decrease of the debit at the well No3 in Zugdidi and well No 2-t Tsaishi there was built additional pumping station with 2,520 m^3/day capacity, and also a heat path from the place to the well No 3 in Zugdidi. In 1983 the pump of the station No 2-t in Tsaishi was replaced with a more productive one, with capacity of 4,320 m^3/day at the same time on the head line there was built a reverse line to the suction allowing to control the deficiency between pump capacity and well productivity by means of a gate. The similar scheme was constructed in 1981 at well No 3 in Zugdidi.

Until the new wells were put into operation, in middle of March, 1981, the total water intake within Zugdidi-Tsaishi deposit was about 7.540 m^3/day (capacity of the two pumping stations + gryphon, i.e. uncontrolled discharge, at well No 3 in Tsaishi with 700 m^3/day discharge). With such a water intake hydrogeological parameter and the level stabilisation was observed at the operating well No 4 in Zugdidi (12.0 m). In the middle of March, 1981, the construction of the well No 3-t in Tsaishi was completed with 800 m^3/day output. The wells No 1-t and 2-t were finished earlier, however, they were closed.

After self-flow was obtained at the well No 3-t in Tsaishi, the water intake from the middle of March to the end of July, 1981 was about 8,340 m^3/day. During the month the water level at the well No 4 in Zugdidi fell down to 13,6 m, and did not change until the end of July, 1981. In the end of July, 1981 the full discharges were started at the wells no 1-t and 2-t in Tsaishi and total water intake initially was about 16,840 m^3/day which continued up to October, 1981. Within this period the total discharge of the deposit, due to discharge decrease of separate wells, fell down to 15,879 m^3/day, and the level of well No 4 in Zugdidi fell down to 20,8 m. Due to sharp fall of the debit on the well No 3 in Zugdidi down to 3,800 m^3/day the well No 1-t in Tsaishi was closed and total water intake, consequently, reduced down to 11,270 m^3/day. The limited discharge was continued until May, 1982. By that time there was observed a gradual decrease of total water intake down to 1002 m^3/day and level fall down to the point 22,4 m. Starting from May 1982, due to finishing of the heating season the pumping station operation was stopped also at the wells No 1-op and 3-Tsaishi, i.e. the water intake of the deposit was reduced down to 7,500 m^3/day. From this time gradual restoration took place till the start of heating season (November 1). Total water intake increased to 8,400 m^3/day by the well debit increase and well No 4 level in Zugdidi rised up to 19,0 m. From November 1982 to May 1983 during heating season besides the pumping of the wells No 1-op and 3 operation in Tsaishi there was started full output from the well No 1-t in Tsaishi and total water intake was increased up to 14,740 m^3/day. The initial water intake amounting to 14,740m^3/day by the end of April, 1983 fell down to 12,940 m^3/day, and the level at the well No 4 in Zugdidi fell down to 30 m.

In May, 1983, again due to finishing of heating season, the wells No 1-op and 3 in Tsaishi were closed and the total water intake amounted to 10,500 m^3/day, at that time. Starting from this period to August of 1983 there was gradual increase of debits on separate wells and the total water intake increased up to 11,100 m^3/day and at the same time, well No 4 level in Zugdidi elevated up to 29,0 m.

In August, 1983 well No 8-t in Tsaishi was drilled with initial discharge amounting to 6,600 m^3/day. By that time the well No 3 in Tsaishi with uncontrolled flow (gryphon) was liquidated. Thus, with the well No 8-t operation in Tsaishi, the total water intake increased up to 17,000 m^3/day and kept on to November, 1983. By November, 1983 separate well discharge considerably decreased, correspondingly the total water intake also decreased down to 15,600 m^3/day. The level of the well No 4 in Zugdidi decreased down to the point of 32,4 m.

With the beginning of heating season, well No 8-t in Tsaishi was connected to the existing pumping station with 2,520 m^3/day output, simultaneously there was opened nearby well No 1-op for self-pouring. The total water intake at the deposit under the circumstances, amounted to 13,720 m^3/day. In the middle of January of 1984 self-flow was ceased on the well No3 in Zugdidi. Total water intake decreased down to 11,620 m^3/day and the well No 4 level in Zugdidi decreased to 33,6 m. From this moment the gradual restoration of debits of wells and levels on No4 in Zugdidi was observed. Restoration took place until the end of the heating season and at that time the full discharge of the well No 8-t in Tsaishi was started. By the end of the heating season, the total water intake increased up to 11,820 m^3/day and well No 4 level in

Zugdidi elevated up to 32,2 m. With the full discharge at well No 8-t in Tsaishi total water intake increased up to 15,600 m^3/day. During May, 1984, there was a sharp falldown of the level (down to 34,4 m) on well No 4 in Zugdidi and insignificant decrease of debits on separate wells, total water intake decreased down to 14,760 m^3/day and was stable till October, 1984. During this period the well No 4 level in Zugdidi to the middle of June fell down to the mark 34,6 m and was stable until the end of October of 1984. Analysis of dependence of the level of well No 4 in Zugdidi from total water intake within 1981-1984 (drawing No 4) leads to the following conclusions

:

-after the well No 3-t in Tsaishi was put into operation in March, 1981 with 800 m^3/day debit, the level on the well No 4 in Zugdidi fell down to 1.6 m and stabilised at the mark of 13.6 m, i.e. at 1.6 m section the debit of deposit increased up to 800 m^3/day;

-the second period of level stabilisation on the well No 4 in Zugdidi at the grade of 34.6 m started while the total water intake of 14,760 m^3/day during May-October, i.e. at 21 m section the total debit of deposit increased by 6,420 m^3/day;

-in the first case specific debit amounted to 500 m^3/day over 1 m, and in the second case to 300;

-with about equal water intake from November, 1981 to April 1982 and January-April, 1984, in the first case there was a level falldown on the well No 4 in Zugdidi, and in the second case - there was level increase; with other equal conditions in the heating season 1982-1983 the total water intake decrease and level fall on well No 4 in Zugdidi was observed, whereas, in June-October period of 1984 the total water intake was stabilised, the same for the level the well No 4 in Zugdidi.

Summarising the above, we can conclude the following:
- continuous operation of the deposit and long-term test discharges have formed large depression cone , its cutting down by 1m enables to increase operation debit by average 400 m^3/day;
-initial location of the conical depression centre was determined by the well No.3 in Zugdidi. After installation of new wells it has shifted to the Tsaishi anticlyne, fold to the south;
-after the self-flow ceasing on the well No 3 in Zugdidi the level stabilisation at total water intake amounting to 14,760 m^3/day takes place during the month, whereas, with the similar conditions but with well No 3 operation in Zugdidi this period lasts up to 4-5 months;
-high efficiency of arch adjacent part of Tsaishi linear fold for creating linear water intake at this location at approximately equal absolute grades for increasing the reserves of thermal waters by drilling of two wells; the first one between wells No 1-t and 8-t and the other one eastwards at 500 m distance away from the well No 8-t.

Thermal water operating reserves calculations were based on a long-term operation analysis and well discharges in Zugdidi-Tsaishi deposit, regular observation data within the period between August, 1983 to October, 1984 (drawing No 4). The regular scheduled observations' results show, that within this period hydrogeological parameter stabilisation at operating wells No 1-op, 8-t, 2-t and observation well levels at well No 4-t in Tsaishi, No 1, 4 in Zugdidi took place in May-October of 1984. The only exception is the well No 6-t, in which gradual increase of the level was observed. This, perhaps, is caused by the fact, that the well was finished recently and the thermal regime is set in near drilled area.

Thus, it has been determined, that the continuous operation of the deposit is possible with existing the scheme (wells No 1-t, 2-t, 8-t and 1-op in Tsaishi; No 3-t is excluded since it could not yield productive inflow) within unlimited period of time with the total output of 14,300 m^3/day.

The main consumer of thermal waters is green-house facilities with 12 Ha of surface area, which is planned to be built here within 1985-1990 under USSR Council of Ministers Statement of 23.09.82 No 880. Besides, with additional resources available, under the same Statement, the green-house output could be increased.

Reserve Categories. It was shown above, that with the total intake up to 14,300 m^3/day (without well No 3-t debit in Tsaishi) there was observed the stabilisation of deposit regime. Besides, the high efficiency of the arch adjacent part of the Tsaishi anticline is determined in terms of linear water intake creation along with additional well drilling. One of these wells, No 9-t should be injected between wells No 1-t and 8-t. These wells represent reserves of "B" category amounting to 2,800 m^3/day as defined for well No 2-t in Tsaishi. By category "A" there are represented the well debits of No 1-op, 1-t and 8-t in the amount of 11,500 m^3/day. Well No 2-t should remain as a backup for future.

It was mentioned above, that the earlier approved reserves (GKZ USSR Statement No 7,384 of 29.04.75) at Zugdidi deposit were $A+B+C_1$ - 24192 m^3/day, including category A -7128 m^3/day and C_1 -17064 m^3/day.

Category C_1 -17,064 m^3/day was established for conditions at 100 m depth.

In Tsaishi the approved water intake reserves of category A+B+C amounted to 3,906 m^3/day. These reserves were based on wells of "Tsaishi" resort and for above mentioned reasons we do not take them into account. New well drilling (No 1-t, 2-t and 8-t) in Tsaishi area enabled to make natural section on the whole deposit at 35-40 m depth and to convert earlier set reserves of category A-7,128 m^3/day in Tsaishi area and C_1 category reserves in the amount of 7,172 m^3/day of categories A+B. Thus, with 35-40 m lowering the supply increase for productive categories by converting earlier approved reserves C_1 -17,064 m^3/day, amounted to 7,172 m^3/day which very exactly correspond to the earlier calculations of specific debit of the deposit (170.64 m^3/day at 1 m level decrease).

By the category C_1 -9,892 m^3/day there are suggested for approval as a difference between approved earlier reserves of category C-17,064 m^3/day and presented reserves for the productive categories amounting to 7172 m^3/day.

Deposit well	Category of the reserves, m/c			Temperature ^{0}C	Mineralization g/l
Zugdidi-Tsaishi well No 1-op, 1-t, 2-t, 8-t	<u>A</u> 11,500	<u>B</u> 2,800	<u>C</u> 9,892	82-86	1.3-1.7
Category A -11,500 m^3/day, B-2,800 m^3/day, C_1-9892 m^3/day, A+B+C_1 - 24,192 m^3/day					

9. Zugdidi - Tsaishi deposit state for industrial developing

In 1975 under estimated condition by 01.01.74 GKZ USSR affirmed thermal water storage ready for use in Rioni cavity (record GKZ N 7384 of 29 IV-1975) using mathematical modelling method. Zugdidi water intake was including by category A-7128 m^3/day and C_1 -17069 m^3/day, so was included Zaishi water intake - 1950 m^3/day (category A+ B) and 1506 m^3/ day (category C_1). Ready for use storage confirmed by GKZ according to Industrial categories was based on well debit of above mentioned water intakes and have been distributed in the following way: wells NN 4,3 Zugdidi - 7128 m^3/day, Tsaishi - 1950 m^3/day.

By the decision of GKZ USSR a supplementary prospecting of both water intakes aimed to transfer C_1 category storage into higher category. Development of green house facilities using thermal waters in Georgian SSR for the last few years let "Grusburgeotermia" to start preliminary geologocal-prospecting works in 1979.

Geologocal-prospecting works and hydrodinamic investigations revealed sharply defined interconnection of these two water intakes and this fact let us to unite these two intakes into one Zugdidi - Tsaishi deposit. Ready for use storage of this deposit was defined as 14300 m^3/day (category A+B).

Analysis of long-term operation shows that putting new wells into operation causes debit drop or failure of artesian flow in existing wells. For example, during the period of 1978-1984 after putting new wells into operation artesian flow in wells NN 3,4 Zugdidi was stopped, which had been stated as belonging to category A with 7128 m^3/day storage. The main factor determining interconnection between old drilled and new drilled wells is hypsometrial mark of their mouth of the hole and also their linear disposition to the perpendicular front of main flow of Neocom complex of underground waters.

This circumstance served as basis for the proposed scheme of operation and further development of geologic and exploration drilling works of two wells between No.8-t and I-t Tsaishi and 500 m away to east from well No.8.

Its implementation will increase set debit of 14 300 m^3/day up to 20 000 thousand m^3/day and will help to encrease capacity of greenhouses under design up to 18 Ha instead of planned 12. Besides, these wells can be used as reserve supplies at peak load. Moreover, in this case water intake will have linear location parallel to the front of underground water movement and absolute marks of existing and designed wells will have equal values.

Thus, existing operating scheme comprises wells NN. I-op,8-т, 2-т with determined storage 1430 m^3/day which fully provides heat supply to 12 Ha of designed green house facilities (enclosure. N.3,6). Operating storage can be increased by drilling of two new wells which will help to design additional 6 Ha of green-house facilities.

10. Economical analysis of performed prospecting works and geological-economical evaluation of Zugdidi - Tsaishi deposit

According to table 18, actual price of works performed by "Grusburgeothermia" in Zugdidi-Tsaishi region is 2 786 130 rubbles, at 15175 m total drilling length. Consequently, cost of one meter of prospecting drilling is 186,6 rubbles and expences for 1 m^3/day of extracted geothermal water is 228,02 rubbles.

Basic rated technical-economical values of future geothermal heat supply system in Zugdidi-Tsaishi region obtained according to the principle scheme of explotation of the deposit, (dwg.12) are given in table 19.

Data show that economical efficiency of investments into business according to the developed scheme of exploitation of deposit and geothermal heat supply system are much better than investment rated coefficient. Thus, deposit exploitation conditions according to proposed version can be considered as acceptable.

These conditions are following:

- minimum average annual output of thermal water intake is 14,3 thousand m^3/d (A+B category);

- minimum average temperature of geothermal water supplied to users is 80^0C;

- all wells shall work on self- flow and geothermal water shall be transported through hot water system with the aid of system of pumps with electric drive.

- Before supply to users the geothermal water shall be degased in vacuum.

Table 18

Main technical-Economical rates of A+B Zugdidi-Tsaishi deposit

NN	Values	measurm. item		
1	Capital investments	thousand roubles	2 063,1	3 870,54
2	Operational expences	" "	383,8	1 020.4
3	Specific capital investments	rouble/GJ rouble/m^3	3,31 0,54	6,22 -
4	Specific operational expences	rouble/GJ rouble/m^3	0,62 0,10	1.62 -
5	Reduced expences	rouble/GJ	1,12	2.72
6	Economic efficiency obtained by switching from organic fuel to geothermal water	thousand roubles/ year	1 569,4	

Table 19

Performed geological-prospecting works and expences for Zugdidi-Tsaishi thermal water deposit preliminary prospecting during 1979-1983 years

NN	Works	Item	Acc. to cost estimate quantity	Total summ (roubles)	Actual completion quantity	Total summ (roubles)
1	Rotary drilling and bolting		13500	1675619	12688	187903
2	Industrial-geophysical works	"	-	72284	-	72065
3	Well checking	well	6	69009	5	62731
4	Laborato-rial works	roubles	-	4922	-	-
5	Transportation	"	-	119260	-	247345
6	Misceluniuos	"	-	361856	-	251559
	Total	roubles	13500	2302950	12688	2512737

CONCLUSION

By the decree of Council of Ministry of the USSR of September 23, 1982, for the Gas Industry Ministry by the department "Gruzgeoterm" of the Scientific Industrial Enterprise "Soyuzburgas" and Tbilisi complex department "VNIPI and Geotherm" of the Scientific Industrial Enterprise "Soyuzburgeotermia" forces was determined the supply amount of Tsaishi thermal water deposit.

The prospecting works, finished beforehand and the following hydrodynamic researches on the stage of counting up supplies has determined, that Zugdidi and Tsaishi water intakes represent the unified hydrodynamic system, bordered from the South by tectonic distortions (Tskhakaia - Tsaishi fracture). That's why these water intakes are represented by us as united Zugdidi - Tsaishi thermal water deposit, operational reserves of which counted up by hydraulic methods as A+B - 143000 m^3/day category are determined.

In 1975 in GKZ USSR (report No. 7384 of 29.04.75) were approved thermal water supplies according to the 01.01.74 year condition, on Zugdidi deposit in amount of 24192 m^3/day (category A+B+C_1). From this amount, 7128 m^3/day (category A) are based on Zugdidi well No.1, 3 debit, and the rest with the amount of 17064 m^3/day (category C_1) by lowering down for 100 m.

Fixed supplies of A - category - 7128 m^3/day, with the redistribution of the water intake main center are confirmed by us on the Tsaishi area (wells No.1-op, 1-t, 2-t, 8-t). Besides, by the natural section on 35-40 m (drilling of new wells on elevations 50-60 m against earlier drilled wells on elevations 93-96 m) is received increase by industrial categories in amount of 7172 m^3/day, at the same time total amount of earlier fixed supplies of A+B+C_1 - 24192 m^3/day remains unchanged.

Hydrogeological prospecting works and following hydrodynamic researches revealed the definite heterogenity of thermowaterbearing complex collection properties, remarkable interaction between wells located on the absolute elevations with the difference of 30-40m and at their location perpendicularly to the underground water movement. This circumstance made possible to attribute deposits to the second group, and to carry out the counting of operating reserves by hydraulic reserves. According to the results of hydrodynamic researches a high perspectivity of fracture zone of Tsaishi linear anticline structure was determined with the aim to drill here two wells of linear water intakes, in parallel to the main underground movement. And the absolute elevations of well offings will be nearly of the same size.

At such well disposition, there will be a minimum chance of interference between them, and water intake center will be moved to the Tsaishi anticline arch part. The presented operational schedule will allow to supply the main water amount to the customer (greenhouses) from this area, and at the peak loading to use wells No.9-t and 10-t. So, it has a big maneuverability.

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Monthly cha

Na+K	NH4	Ca	Mg	Fe	Cu	Mn	Mo	Zn	Cl	SO4
254,38 46,69	нет	2I2,42 39,70	38,9I I3,52	нет	нет	нет	нет	нет	29I,I0 24,6I	674,6[illegible] 59,3[illegible]
226,32 4I,54	нет	2I4,42 45,I6	40,I2 I3,3	нет	нет	нет	нет	нет	24I,40 28,7I	688,2[illegible] 60,5[illegible]
238,28 42,68	0,20 0,06	2I4,42 44,08	38,9I I3,I8	нет	нет	нет	нет	нет	248,50 28,84	699,3[illegible] 60,0[illegible]
24I,96 43,25	нет	2I4,42 43,99	37,69 I2,76	нет	нет	нет	нет	нет	248,50 28,78	70I,8[illegible] 60,I[illegible]
388,26 53,73	0,70 0,I3	2I4,43 24,05	46,2I I2,09	-	нет	нет	нет	нет	305,30 27,37	678,3[illegible] 44,9[illegible]
225,63 39,0I	0,70 -	236,47 46,92	42,56 I3,9	нет	нет	нет	нет	нет	287,56 32,20	689,0[illegible] 57,I[illegible]
268,20 45,06	нет	2I6,43 42,69	37,69 I2,25	нет	нет	нет	нет	нет	29I,I0 32,4I	693,2[illegible] 57,03
233,45 4I,I8	следы	220,44 44,63	42,56 I4,I9	нет	нет	нет	нет	нет	284,00 32,45	675,5I 57,08
[illegible]45,87 4I,45	0,03 -	236,47 45,75	38,9I I2,8	нет	нет	нет	нет	нет	305,30 33,35	69I,I5 55,80
[illegible]3I,85 [illegible]2,97	нет	228,45 44,74	37,69 I2,I6	нет	нет	нет	нет	нет	298,20 32,96	684,I5 55,92
[illegible]54,84 [illegible]3,43	0,70 0,I3	224,44 43,90	38,9I I2,54	-	нет	нет	нет	нет	208,20 32,92	685,80 55,97
[illegible]19,7 [illegible]2,80	нет	228,3 45,0I	37,69 I2,I9	нет	нет	нет	нет	нет	2I2,I 25,95	693,2 62,66

Central chemical laboratory of Geological De

...nical tests results of Tsaishi well N4 thermal water during

mg / l
equiv. %

Table 13

NO_3	NO_2	CO_3	HCO_3	F	Br	J	H_4SiO_4	SiO_2	HBO_2	B	As	Fe
нет	нет	нет	I52,50 I5,63	2,I00 0,4I	0,I3 0,04	0,42	36,52	30	I,68	0,4	нет	–
нет	нет	нет	I58,60 I0,34	2,00 0,4I	0,I3 0,04	0,42	36,52	–	I,69	0,42	нет	–
нет	нет	нет	I58,60 I0,7I	2,00 0,42	0,66	0,25	–	–	I,73	0,43	нет	–
нет	нет	нет	I58,60 I0,69	2,00 0,42	0,66	0,I6	–	–	I,I3	0,43	нет	–
нет	нет	нет	I58,60 27,37	I,60 0,25	0,80 0,03	0,I2	–	–	–	–	нет	–
нет	нет	нет	I58,60 I0,34	I,60 0,32	0,80 0,04	–	83,2	52,0	–	следы	нет	нет
нет	нет	нет	I58,60 I0,29	I,40 0,28	0,74 –	нет	54	34	3,55	0,88	нет	н т
нет	нет	нет	I52,50 I0,I4	I,40 0,29	0,79 0,04	нет	54	34	3,6	0,3	нет	н т
нет	нет	нет	I64,70 I0,47	I,80 0,35	0,82 0,04	–	80	50	I,2I	0,30	нет	н г
нет	нет	нет	I64,70 I0,59	2,4 0,47	0,93 0,06	0,42 –	4I,34 –	26	3,47	0,3	нет	н !
нет	нет	нет	I64,70 I0,58	2,40 0,47	0,93 0,06	0,52 –	4I,34	26	–	–	нет	
нет	нет	нет	I58,60 II,30	I,80 0,04	0,80 0,05	нет	48,4	24,2	–	–	нет	н

...artment of Georgia

1983

pH	Rigidity	Dry residue mg/e	Chemical consistency formula:
6,8	I3,8	I590	$M_{I,655}\frac{SO_4\,59\;Cl\,25\;HCO_3\,16}{(Na+K)\,67\;Ca\,40\;Mg\,13}$
6,8	I4,0	I540	$M_{I,6}\frac{SO_4\,61\;Cl\,29\;HCO_3\,10}{Ca\,45\;(Na+K)\,42\;Mg\,13}$
6,8	I3,9	I575	$M_{I,62}\frac{SO_4\,60\;Cl\,29\;HCO_3\,11}{Ca\,44\;(Na+K)\,43\;Mg\,13}$
6,6	I3,8	I590	$M_{I,63}\frac{SO_4\,60\;Cl\,29\;HCO_3\,11}{Ca\,44\;(Na+K)\,43\;Mg\,13}$.
6,8	I4,50	I778	$M_{I,83}\frac{SO_4\,45\;HCO_3\,27\;Cl\,27}{Ca\,24\;(Na+K)\,54\;Mg\,12}$
6,9	I5,30	I642	$M_{I,63}\frac{SO_4\,57\;Cl\,32\;HCO_3\,10}{Ca\,47\;(Na+K)\,39\;Mg\,14}$
6,8	I3,90	I650	$M_{I,699}\frac{SO_4\,57\;Cl\,32\;HCO_3\,10}{Ca\,43\;(Na+K)\,45\;Mg\,12}$
7,0	I4,50	I600	$M_{I,647}\frac{SO_4\,57\;Cl\,32\;HCO_3\,10}{Ca\,45\;(Na+K)\,41\;Mg\,14}$
6,8	I5,I0	I684	$M_{I,736}\frac{SO_4\,56\;Cl\,33\;HCO_3\,10}{Ca\,46\;(Na+K)\,41\;Mg\,13}$
6,8	I4,5	I666	$M_{I,69}\frac{SO_4\,56\;Cl\,33\;HCO_3\,11}{Ca\,45\;(Na+K)\,43\;Mg\,12}$
6,8	I4,4	I674	$M_{I.70}\frac{SO_4\,56\;Cl\,33\;HCO_3\,11}{Ca\,44\;(Na+K)\,43\;Mg\,12}$
6,8	I4,4	I589	$M_{I,60}\frac{SO_4\,63\;Cl\,26\;HCO_3\,11}{Ca\,45\;(Na+K)\,43\;Mg\,12}$

1983

-e	pH	Rigidity	Dry residue mg/e	Chemical consistency formula
-	7.I	8.6	905	$M_{0.[illegible]} \frac{SO_4\,60\;Cl\,20\;HCO_3\,19}{Ca\,47\,(Na+K)\,38\;Mg\,14}$
-	7.2	9.6		$M_{I.06} \frac{SO_4\,62\;HCO_3\,19\;Cl\,18}{Ca\,50\,(Na+K)\,36\;Mg\,14}$
-	7.0	8.4	916	$M_{0.97} \frac{SO_4\,59\;Cl\,21\;HCO_3\,18}{Ca\,44\,(Na+K)\,40\;Mg\,16}$
-	6.9	7.8	894	$M_{0.95} \frac{SO_4\,59\;Cl\,22\;HCO_3\,18}{Ca\,46\,(Na+K)\,43\;Mg\,11}$
-	6.9	9.9	878	$M_{0.[illegible]} \frac{SO_4\,60\;Cl\,21\;HCO_3\,19}{Ca\,55\,(Na+K)\,26\;Mg\,19}$
-	6.8	9.4	874	$M_{0.[illegible]} \frac{SO_4\,66\;Cl\,20\;HCO_3\,19}{Ca\,53\,(Na+K)\,30\;Mg\,17}$
ICT	7.2	9.00	816	$M_{0.[illegible]} \frac{SO_4\,59\;Cl\,22\;HCO_3\,19}{Ca\,56\,(Na+K)\,26\;Mg\,18}$
-	6.8	9.10	944	$M_{0.[illegible]} \frac{SO_4\,64\;Cl\,18\;HCO_3\,18}{Ca\,46\,(Na+K)\,36\;Mg\,18}$
IGT	6.8	9.00	852	$M_{0.[illegible]} \frac{SO_4\,61\;Cl\,22\;HCO_3\,18}{Ca\,53\,(Na+K)\,30\;Mg\,16}$
-	6.8	9.10	848	$M_{0.[illegible]} \frac{SO_4\,60\;Cl\,22\;HCO_3\,18}{Ca\,54\,(Na+K)\,30\;Mg\,16}$
-	[illegible]	[illegible]	970	$M_{0.[illegible]} \frac{SO_4\,60\;Cl\,21\;HCO_3\,18}{Ca\,47\,(Na+K)\,37\;Mg\,16}$
-	6.9	8.6	894	$M_{0.95} \frac{SO_4\,56\;Cl\,22\;HCO_3\,22}{Ca\,48\,(Na+K)\,38\;Mg\,14}$

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Monthly chemical tests results of Zugdidi well N3 thermal water during

mg/l
equiv. %

Table 12

	Na+K	NH4	Ca	Mg	Fe	Cu	Mn	Mo	Zn	Cl	SO4	NO3	NO2	CO3	HCO3	F	Br	J	H4SiO4	SiO2	HBO2	B	As	F
[illegible]	123,05 38,35	нет	132,26 47,31	24,32 14,34	–	нет	нет	нет	нет	99,40 20,07	403,17 60,17	нет	нет	нет	164,70 19,35	1,20 0,44	0,26 –	–	47,7	–	1,73	0,43	нет	
[illegible]	121,67 35,52	нет	143,29 49,69	26,75 14,79	–	нет	нет	нет	нет	99,40 18,80	442,25 61,85	нет	нет	нет	170,80 18,80	1,60 0,55	0,26 –	–	47,7	–	1,73	0,43	нет	
[illegible]	128,80 40,00	нет	124,24 44,28	26,75 15,72	–	нет	нет	нет	нет	106,50 21,22	339,46 59,42	нет	нет	нет	152,60 18,57	1,60 0,59	0,21	traces ~~следы~~	34	–	–	0,43	нет	
[illegible]	133,17 42,60	нет	126,25 46,36	18,24 11,04	нет	нет	нет	нет	нет	106,50 22,03	385,07 59,02	нет	нет	нет	152,50 18,33	1,40 0,51	traces ~~следы~~	нет	44,8	28	нет	нет	нет	
[illegible]	79,35 25,84	нет	146,29 54,68	31,62 19,49	нет	нет	нет	нет	нет	99,40 20,97	383,01 59,78	нет	нет	нет	152,50 18,73	1,20 0,45	1,06 0,07	traces ~~следы~~	48,0	30	нет	нет	нет	
[illegible]	92,00 25,93	нет	142,28 52,99	27,79 17,16	нет	нет	нет	нет	нет	95,65 20,15	385,89 63,00	нет	нет	нет	158,60 19,40	1,20 0,45	traces ~~следы~~	нет	32	20	–	нет	нет	
[illegible]	74,06	нет	140,29 56,36	26,75 17,71	нет	нет	нет	нет	нет	95,65 21,74	349,27 58,53	нет	нет	нет	146,40 19,32	–	traces ~~следы~~	нет	50,8	32	2,55	0,[illegible]	нет	1
[illegible]	116,61 35,77	нет	130,26 45,88	31,61 18,35	нет	нет	нет	нет	нет	92,30 18,34	403,20 63,65	нет	нет	нет	152,50 17,65	1,20 0,25	–	–	50,8	[illegible],0	[illegible]	0,8[?]	нет	
[illegible]	90,16 30,34	0,1	138,27 53,41	25,53 16,25	tr сл	нет	нет	нет	нет	99,40 21,67	380,54 60,53	нет	нет	нет	140,30 17,80		traces ~~следы~~	нет	44,80	28	0,10	–	нет	1
[illegible]	88,50 29,73	0,10	140,28 54,05	25,53 16,22	tr сл	нет	нет	нет	нет	99,40 21,62	372,31 59,85	нет	нет	нет	146,40 18,53	–	traces ~~следы~~	нет	–	28	0,40	0,1	нет	
[illegible]	120,52 37,32	нет	132,25 47,01	26,75 15,67	–	нет	нет	нет	нет	106,50 21,37	408,00 60,[illegible]	нет	нет	нет	152,50 17,81	1,6 0,56	0,26		47,7	30	[illegible]	1,29	нет	
[illegible]	122,4 37,32	нет	134,32 47,90	24,32 14,18	нет	нет	нет	нет	нет	99,40 21,81	406,25 [illegible]	нет	нет	нет	153,40 22,00	1,6 0,56	traces ~~следы~~	нет	48,0	30,[illegible]	1,[illegible]4	0,43	нет	

[illegible] of Geological Department of Georgia

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