

*Physical Geography*

## Clay-Slates Brought by Duruji River and Viticulture in Inner Kakheti

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**ABSTRACT.** The micro-zones of Kindzmarauli, Kvareli and Napareuli vineyards cover the bodies – alluvial fans of Duruji River. Weathered clay slates brought down by Duruji River cover the areas adjacent to Duruji riverbed creating the ground, soil layer of the mentioned natural micro-zones [1]. And this typical layer, together with local climatic conditions comprise the mentioned micro-zones for growing high quality Kindzmarauli, Kvareli and Napareuli vineyards. To ensure quality and the best taste of the wine, it is recommended to spread the weathered material brought down by Duruji River into the vineyards of Inner Kakheti (disposed of the large stones). In this way physical characteristics, color and chemical composition of the soil is changed substantially improving the quality of the produced wine. This will additionally provide periodical cleaning of the riverbed preventing expected mudflow disasters. © 2017 Bull. Georg. Natl. Acad. Sci.

**Key words:** clay-slate, wine quality, total active temperatures, Duruji River

The Subject of our research is Inner Kakheti lowlands (plains) and foothills including the zone of 300-600 m absolute altitude above sea level, where natural agrarian-climatic conditions are very favorable for growing and cultivation of high quality grapes.

This is the territory, where natural micro-zones are formed for cultivation of such high quality grapes as Kindzmarauli, Napareuli, Kvareli. The authors of this article indicate that local, substantially unique agrarian-climatic conditions are created (and are creating even now) by the weathered clay slates of dark (almost black) color brought by Duruji River.

One of the goals of our research is seeking the ways for expansion of the area of the mentioned mi-

cro-zones through artificial removal of the weathered clay slate from Duruji River to the territory of the remained part of the Inner Kakheti plains and foothills.

Inner Kakheti is located between Greater Caucasus from one side and Gombori Mountain Range and Iori Highlands - from the other. It continues in the territory of Azerbaijan, as Agrichai plain. In the Eastern Georgia there is delicate and mild climate. These natural conditions ensure amplexness of agriculture in Kakheti – just remember local vine-growing and local wines widely known for their fine bouquet [2].

Climate in Inner Kakheti differs significantly from the remainder of Eastern Georgia located at the same

altitude. Its mildly humid subtropical climate is characterized with hot summer and moderately cold winter. Climate and soils here contribute to development of agriculture and particularly of viticulture.

Sunshine duration is over 2300 hours. Total solar radiation on the left side of Alazani River is 110-120 Kcal/cm<sup>2</sup> and on the eastern side - 120-139 Kcal/cm<sup>2</sup>. This is due to significant cloudiness along the left side. Radiation balance on the right side exceeds 51 Kcal/cm<sup>2</sup>.

Annual precipitation is 1070 mm. Minimal precipitation – 40 mm is in winter (January) and maximal – 181 mm – in May. In the cold period precipitation is 265 mm while in the warm period this figure is 805. Number of days with precipitation is 132. Hail-hit days amount to 2.1. It is most frequent in May (0.9 days). In the remained days of vegetation period hail is for 0.1-0.3 days. Average relative annual humidity is 72%. In the driest month – August – relative humidity is 64%. In the same month the lowest relative humidity at 1 PM relative humidity is 48%.

In Inner Kakheta the winds blow mostly along Alazani River gorge. In the cold time there are mostly east and north-east winds and in summer – west and south-west winds. Summer winds from the south (from Azerbaijan) bring additional warmth and this further increases the heat regime of the region. Average annual wind velocity is quite low, 1.2 m/sec in average [3,4].

Vine belongs to small group of agricultural crops especially sensitive to the changes of environmental conditions. The wine reflects like a mirror its variety and localization of its production. Saperavi produced in Kakheta is absolutely different from the wine made from the same grape variety in Crimea [5].

Quality of the produced wine, together with the climate, is determined by the soil. The soil not only supplies the plants with nutrition but also largely impacts the aroma and taste of the wine made of the harvested grapes. In Inner Kakheta the soil (alluvial non-calcareous skeletal, carbonate-clay loam, forest brown and gray, meadow gray-brown soils) are very

favorable for production of the unique grape varieties. In particular, the grapes yielded at the southern foothills of Greater Caucasus and, especially river alluvial fans, produce table wines with finest aroma and the best quality.

On the southern slope of Greater Caucasus in Kakheta there is Duruji River basin. In the upper reaches it is represented by two tributaries – Black and White Duruji. Their upper reaches are located in the alpine zone. Black Duruji originates from Mt. Black Cliff and White Duruji River – from the slopes of Mt. Ninikastsikhe.

Duruji River length is 27 km, catchment area – 103 km<sup>2</sup>. The river is mostly fed by the melted and rain waters; it is shallow. Average annual discharge is 1.06 m<sup>3</sup>/sec; the River is characterized with floody regime. Black Duruji has more bank cuttings compared with White Duruji. Height of its exposed slopes varies between 500 m and 1 km, while width is over 4 km. Clayey slates of Lower Jurassic period building these slopes are extensively weathered and as a result there is abundance of the weathered materials.

Along the exposed areas of Black Duruji, especially on the Black Cliff there are developed long and wide depressions and the weathered materials permanently flow along these depressions. Significant landslides contribute to formation of the torrent deposits. In upper reaches of Duruji River typical mudflows emerge periodically and at that times water discharge can achieve 200m<sup>3</sup>/sec and even more. They bring down hard materials from the mountains transformed into mud and endangering city of Kvareli.

Natural materials' migration as a result of mudflow processes achieves up to 20 million m<sup>3</sup>; annual quantity of the material is about 500 thousand tons. Mentioned loose material is non-homogenous mixture of crashed clay slates of gray color (80%) and boulders, including rocky pieces – 20%.

Alluvial fan from Duruji River covers Kindzmarauli, Kvareli and Napareuli micro-zones of viticulture where the alluvial material creates unique conditions for production of the fine wines.

Solar energy makes Duruji River alluvial fan (area 10x6.5 km<sup>2</sup>) covered with blackish slate much warmer. The same could be said about Chelta and Burkha river valleys. As a result, in the micro-zone the temperatures of the soil and air layer immediately adjacent to it are 2-3°C warmer compared with the surrounding areas. On the opposite side there are well known micro-zones of Napareuli, Kindzmarauli, Kvareli and other high quality wines.

At the available areas located within 350-450 m over the sea level the total of active temperatures varies between 4050 and 3850°C. Naturally, accumulation of the sufficient heat of 4000°C in the lower areas will be ensured in approximately 50% of years (once per two years); at 450 altitude, where the total of active temperatures is 3850°C, this takes place in 25% of years (i.e. once per four years); in the 500 m altitude zone the material for naturally semi-sweet wines will be yielded in 5% of years (5 times per 100 years).

Viticulture zone of Napareuli brand wine is located on the left side of Alazani River, at 350-500 m altitude, on the southern slope of Caucasus mountain range. In the micro-zone of 300 m altitude, where the total of accumulated active temperatures is 4250°C, the material for naturally semi-sweet wines will be obtained in 70% of years, i.e. 7 times per 10 years; at the altitude of 400 m the naturally semi-sweet wine material will be yielded in 25% of years, i.e. once every four years; at the altitude of 500 m, in case of accumulation of 4000°C heat, the naturally semi-sweet wine material will be yielded in 10% of years only, i.e. once per decade. For production of Napareuli wine material Saperavi grapes must have over 19% sugar content. The brand was developed in 1890; the wine was awarded 7 golden, 4 silver and numerous bronze medals.

Micro-zone of Kindzmarauli brand wine is located on the valley of Duruji – the left tributary of Alazani River. In this micro-zone the temperature of the top-soil and adjacent air is 2-3°C higher compared with the surrounding area. Total of the active temperatures accumulated in Kindzmarauli micro-zone is 4150

°C in average and in this case total heat quantity varies from 3850 (95%) to 4400 (10% of years).

Basic sugar content in the micro-zone should exceed 22% and frequently it exceeds 26-27%, acidity – 5-7 g/dm<sup>3</sup>. Natural originality of Kindzmarauli micro-zone, local climate and soils there provide conditions for production of Kindzmarauli wine. The brand was developed in 1942. The wine was awarded 5 golden, 7 silver and numerous bronze medals.

Kvareli vine-growing micro-zone is located at 400 m over the sea level, on the left side of Alazani River, 28-30 km southwards from Napareuli. Precipitation here is relatively higher than in Napareuli micro-zone. In addition, significant cloudiness and shorter period of sunshine, as well as the other agrarian-climatic conditions result in the delicate flavor of wine materials. Wine Kvareli made of Saperavi grapes in this micro-zone was awarded 4 golden and 3 silver medals.

We regard that high quality of wines made in Napareuli, Kvareli and Kindzmarauli micro-zones is due to the loose materials from Duruji River covering the mentioned territory. To test this hypothesis, in 2010, in Telavi, in one of the vineyards, on 50m<sup>2</sup> area we spread the loose material brought by Duruji River. As a result the soil temperature increased by 3-4°C. Black slates enriched the soil, improved its aeration and in the following years, 2011-2014, impacted positively the wine taste. Certainly, nothing prevents from replicating this on the larger areas - in particular, spread the blackish loose material from Duruji River in the vineyards that will absorb additional heat, increase average daily air temperature totals by 300-400°C, improve soil aeration and positively impact the grapes taste and hence – the quality of wines.

Loose material applied in Telavi District caused heating of the soil to 4-5°C higher temperatures, especially at noon time. While in the morning hours, before sunrise, its temperature was almost the same as at the adjacent land area. At the test land plot the temperature of air layer adjacent to soil (at 2 m height), when there was no wind, was in average 3-4°C higher.

**Table 1. Test Act No: 0317, 06.02.2015**

Humus, %	Carbonates CaCO <sub>3</sub> , (%)	7.7	Forms of absorption of the nutrients (mg/100g)		
			N	P <sub>2</sub> O <sub>5</sub>	K <sub>2</sub> O
2.03	0.3		3.8	1.0	2.2

**Table 2. Here we provide materials offered by G.A. Maghalashvili for 1999 for comparison.**

Humus, %	C . %	7.2-7.7	Chemical composition			
			CaO	Na <sub>2</sub> O	P <sub>2</sub> O <sub>5</sub>	K <sub>2</sub> O
2.5-2.96	0.20-3.00		2.63-2.70	2.00	0.25-0.26	4.0

This could increase of total heat by 300-400°C during the vegetation period resulting in growth of sugar content in gapes, thus significantly improving the quality of produced wines.

In February 2015 the lab test of the clay slate brought down by Duruji River was conducted:

The mentioned materials show that the clay slates from Duruji River contain agrochemically useful substances offering that they could be suitable for application for the vineyards (after removal of the boulders). This proposal was confirmed by our experiment as mentioned above.

The Tables 1, 2, show that the loose material from Duruji River contains humus and nutrients required for the plants – nitrogen, phosphor, potassium. Therefore, its application for the vineyards yield positive results. The same could be said about pH. In our case it was 7.7, i.e. the soil is mildly alkaline. According to the available data [6] on the carbonate soils where pH=7.8-7.9, in France, Germany, Portugal and Italy they produce fine wines.

We recommend application of clay slates from Duruji River at the vineyards. It contains sufficient quantities of the pebbles and small stones good for the vineyards; we should mention dark gray, almost black color of Duruji slates. This contributes to absorption of additional heat making the soil and adjacent air warmer [6].

We cannot agree with the proposal of [7] that the clay slates are useful as fertilizers for all agricultural crops. Presence of the limited quantities of chemical elements, in the weathered material, dark color of pebbles there allow its recommendation for the vineyards only. Our studies showed that there is high correlation between the total temperatures above 10°C and wine quality [1, 8].

Generalization of the data of micro-zones of Inner Kakhети, the products made of Rkatsiteli, Saperavi are of poor quality if the total of active temperatures is less than 3560°; the quality is average within the interval from 3565° to 3740°, good – 3745°-3840° and very good at 3845° and higher. As mentioned above, if the weathered material brought by Duruji River is applied for the vineyards in the vegetation period the total of active temperatures is 300-400°C higher, thus significantly improving the quality of the produced wine.

For improvement of the wine quality and its taste, it is recommended that the weathered material brought down by Duruji River was applied for the vineyards of Inner Kakhети. This will improve physical properties, color and chemical composition of the soil; all these would significantly improve the quality of the produced wines. In addition, the riverbed of Duruji will be periodically cleaned thus preventing expected mudflow disasters.

## ფიზიკური გეოგრაფია

# მდინარე დურუჯის ჩამონატანი და შიგა კახეთის მეღვინეობა

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(წარმოდგენილია აკადემიის წევრის თ. ჭელიძის მიერ)

გეოგრაფიული ადგილის ტემპერატურული რეჟიმის ჩამოყალიბებაზე გადამწყვეტი მნიშვნელობა აქვს ქვეფენილი ზედაპირის ოპტიკურ თვისებებს. კერძოდ, მისი შთანთქმის უნარს. რაც მუქია ქვეფენილი ზედაპირი, მით მეტია მისი ტემპერატურა. მსგავსი თერმული პირობები იქმნება შხის ნათების ხანგრძლივობისას, ე.ი. რაც მეტია შხის ნათების ხანგრძლივობა, მით მეტია აქტიურ ტემპერატურათა ჯამი ( $dt^0 > 10^0$ ).

ნაშრომის მიზანია ფაქტიურ მონაცემებზე დაყრდნობით, მდინარე დურუჯის ჩამონატანი ნაშალი მასალისა (თიხა-ფიქლები) და მიმდებარე ტერიტორიის ჰაერის ტემპერატურას შორის სინქრონული რეჟიმის შესწავლა და იმ კანონზომიერების დადგენა, რომელიც იქმნება მთავარ ოროგრაფიულ ერთეულზე - ალაზნის აკუმულაციური ველი, სადაც გამოდის მდინარე დურუჯი, რომელიც უცვლის ფერს ქვეფენილ ზედაპირს, ამუქებს რა მას და ამით მაღალ თერმულ პირობებს ქმნის ჯერ ყურძნის და მერე ღვინის საუკეთესო ხარისხის მისაღებად.

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