Appendix 12.1 – Geological Information

Detailed Geological Descriptions

Alluvial sediments (al)

The alluvial sediments are quite present in the Kicevo valley and along the rivers with a maximum thickness of the deposited material of 30-50 meters. These sediments are composed of sands, gravels and sandy clays lying above the Pliocene sediments. In the phase of investigation of the location in question in these lithological units at several locations are noticed wet zone as well as occurrence of groundwater.

Diluvial sediments (d)

The diluvial sediments are composed of materials caused by decomposition of the local rock masses which are covered with mixed clayey material, which conditions variable structure and depending on the morphological characteristics, a variable depth. Within the diluvial sediments is present also a variable quantity of fragments of local rock masses.

Proluvial sediments (pr)

The proluvial sediments are widespread in the peripheral parts of the Kicevo valley that overlap the Pliocene sediments and older Paleozoic rock masses. They are composed of rough clastic material, unclassified partly processed materials and they are mixed with clay substance with characteristic yellowish-reddish color.

Pliocene ($Pl_{2,3}$)

Pliocene sediments are present along the boundary parts in the Kicevo valley which lie transgressive through the Paleozoic schists. In the uppermost parts the Pliocene sediments are built of gravels and clays, which in the depths change into clayey sands and clays. Directly to the route itself near the village of Gorno and Dolno Stremogiste, the village of Crvevci is registered coal with insignificant thickness.

Quartzite (QD)

Quartzite appear as smaller masses with expressed massiveness and bedding. They are most frequently composed of isometric quartz grains, expressed with dark-grey color.

Green schists (Sco)

These rock masses are characterized by an expressed shrinkage and depending on the major minerals they are divided into the following types of rock masses: chlorite-sericite schists, quartz-sericite schists, epidote-amphibolite schists, etc. Such rocks are often replaced and transited into each other, both horizontally and vertically.

Quartz metasandstones (Sq)

The quartz metasandstones occur in the upper parts of the phyllites where they are facies replaced, both laterally and vertically with the phyllites. They are characterized by massive at places schist texture, composed of quartz grains which are well rounded, and rarely can be seen feldspars, mica, zircons, tourmaline, etc. The binder is silicon, sericite-clayey and limonite.

Phyllites (Sqse)

It is a group of rocks that are dominated by phyllites, but there are also metasandstones, metalevroiites, sericite-quartz schists, graphite schists and others. Such rocks are often replaced and transited into each other, both horizontally and vertically. Given the wide range of rock masses that appear in this complex, there are also different structural - geological forms (structure, texture, way of appearance, color of rock mass, etc.).

Geomorphological characteristics

In correlation with the geological development and the geological processes that took place on the investigated field are the geomorphological characteristics of the field.

The relief configuration of the field along which is designed the investigated section, which extends in the western part of the Republic of North Macedonia is of hilly-plain character. The territorially and spatially investigated field extends in the Municipality of Zajas and the Municipality of Kicevo, with the beginning of the designed section in the immediate vicinity of the village Bukojcani, and it extends on the left side of the Gostivar-Kicevo highway, 9.5 km long, where in the vicinity to the village Trapchin Dol crosses the mentioned highway and the railway line Gostivar-Kicevo and until the completion of the designed section length of 12.7 km extends on the right side of the highway in the immediate vicinity of the city of Kicevo, where it will join on the highway A2, section Kichevo-Ohrid, which is in the stage of construction.

The morphology of the field shows a relatively complicated state, which is caused by the interaction of the geologic - tectonic, neotectonic, hydrological and contemporary processes of denudation, which together contributed to the process of the formation of today's relief.

The beginning of the route in question is located close to the village Bukocani where the field has a hilly character and is the highest point on the designed route with 840 m above sea level, with a conditionally favorable inclination on the ground of 10-15%. At one part of the field, more precisely at chainage 1+020 km, are registered contemporary linear erosions which are formed with atmospheric rainfall in correlation with the relief configuration of the field. The hilly character of the field extends up to chainage 2+500 km before the entrance to the village Dolno Stogomiste, where the field gradually crosses to flat and stretches to chainage 3+360 km. In the flat part of the route, quaternary deposits are present, where a wet zone is registered at chainage 2+925 to 3+225 km.

The field along the route from the chainage 3+360 km to the chainage 7+100 km has a hilly character. The hilly field through which passes the designed route is characterized by a large intersection of torrential streams, watercourse and great steepness of the slopes on the field. For the leveling solution of the route is paid great attention, because the route passes through extremely difficult natural configuration. Due to that, is foreseen construction of structures (viaducts), while at chainage 4+100 km to 4+800 km where the field has a very large inclination with an elevation of the field of 750 m up to 830 m above sea level, is designed tunnel with length of 730 meters. According to the morphological character, it can be concluded that it would represent the most difficult part for the construction of the highway solution, where for the construction of the above mentioned structures it is necessary to perform access roads to reach to them.

From the chainage 7+100 km to 9+600 km the structure extends in the field with flat character, and it is characterized by a uniform configuration of the field. The route would be performed in embankment with performance of bridge on the River Zajaska and the road knot Kicevo Sever, where the newly designed route passes over the Gostivar-Kicevo highway and the railroad Gostivar-Kicevo and the same gradually turns into a field with a hilly character. In the immediate vicinity of the left but more emphasized on the right bank along the river Zajska is registered a wet zone. For most of the year, river Zajaska is cast out of its river bed, which is not properly regulated. For the performance of this part of the road section, it will be necessary for the river Zajska to be properly regulated.

The field in length of 9+600 km to the end of the designed route 12+728 km extends into field of hilly character, by extending the route on the slopes is characterized by a large intersection of torrential streams, watercourse and great steepness of the slopes on the field. The section in this part extends to a settlement near the village Rastani and the village Osoj and ends with the connection of the highway A2, section Kicevo-Ohrid.

Figure 13 Morphological field characteristics

(left picture-hilly field with occurrence of linear erosion)
(right picture-flat field with occurrence of wet zone)

In correlation with the geological development and the geological processes that took place on the investigated field are the geomorphological characteristics of the field.

The relief configuration of the field along which is designed the researched section, which extends in the western part of the Republic of Macedonia is of hilly-plain character. The territorially and spatially researched field extends in the Municipality of Zajas and the Municipality of Kicevo, with the beginning of the designed section in the immediate vicinity of the village Bukojani, and it extends on the left side of the Gostivar-Kicevo highway, 9.5 km long, where in the vicinity to the village Trapchin Dol crosses the mentioned highway and the railway line Gostivar-Kicevo and until the completion of the designed section length of 12.7 km extends on the right side of the highway in the immediate vicinity of the city of Kicevo, where it will join on the highway A2, section Kichevo-Ohrid, which is in the stage of construction.

The morphology of the field shows a relatively complicated state, which is caused by the interaction of the geologic - tectonic, neotectonic, hydrological and contemporary processes of disintegration (denudation), which together contributed to the process of the formation of today's relief.

The beginning of the route in question is located close to the village Bukocani where the field has a hilly character and is the highest point on the designed route with 860 m above sea level, with a conditionally favorable inclination on the ground of 10-15%. At one part of the field, more precisely at chainage 1+020 km, are registered contemporary linear erosions which are formed with atmospheric rainfall in correlation with the relief configuration of the field. The hilly character of the field extends up to chainage 2+500 km before the entrance to the village Dolno Stogomiste, where the field gradually crosses to flat and stretches to chainage 3+360 km. In the flat part of the route, quaternary deposits are present, where a wet zone is registered at chainage 2+940 to 3+240 km.

The field along the route from the chainage 3+360 km to the chainage 7+100 km has a hilly character. The hilly field through which passes the designed route is characterized by a large intersection of torrential streams, watercourse and great steepness of the slopes on the field. For the leveling solution of the route is paid great attention, because the route passes through extremely difficult natural configuration. Due to that, is foreseen construction of structures (viaducts), while at chainage 4+100 km to 4+800 km where the field has a very large inclination with an elevation of the field of 750 m up to 830 m above sea level, is designed tunnel with length of 550 meters. According to the morphological character, it can be concluded that it would represent the most difficult part for the construction of the highway solution, where for the construction of the above mentioned structures it is necessary to perform access roads to reach to them.

From the chainage 7+100 km to 9+600 km the structure extends in the field with flat character, and it is characterized by a uniform configuration of the field. The route would be performed in embankment with performance of bridge on the River Zajaska and the road knot Kicevo Sever, where the newly designed route passes over the Gostivar-Kicevo highway and the railroad Gostivar-Kicevo and the same gradually turns into a field with a hilly character. In the immediate vicinity of the left but more emphasized on the right bank along the river Zajaska is registered a wet zone.

The field in length of 9+600 km to the end of the designed route 12+728 km extends into field of hilly character, by extending the route on the slopes of the mountain Bistra is characterized by a large intersection of torrential streams, watercourse and great steepness of the slopes on the field. The section in this part extends to a settlement near the village Rastani and the village Osoj and ends with the connection of the highway A2, section Kicevo-Ohrid.

Soil characteristics

Below there is brief description of the soils that can be found along the road, according to Filipovski (2006)[1]:

- *Brown forest soil – (cambisol) -* main differential characteristic of this type of soil is the presence of typical (regular) cambic horizon which is combined in the solum with ochric, mollic or umbric horizon. It is mainly composed of non-carbonate, quartz and silicate compact rocks (acidic, transitional, basic and

[1] Classification of the soils in the Republic of Macedonia, Filipovski, 2006

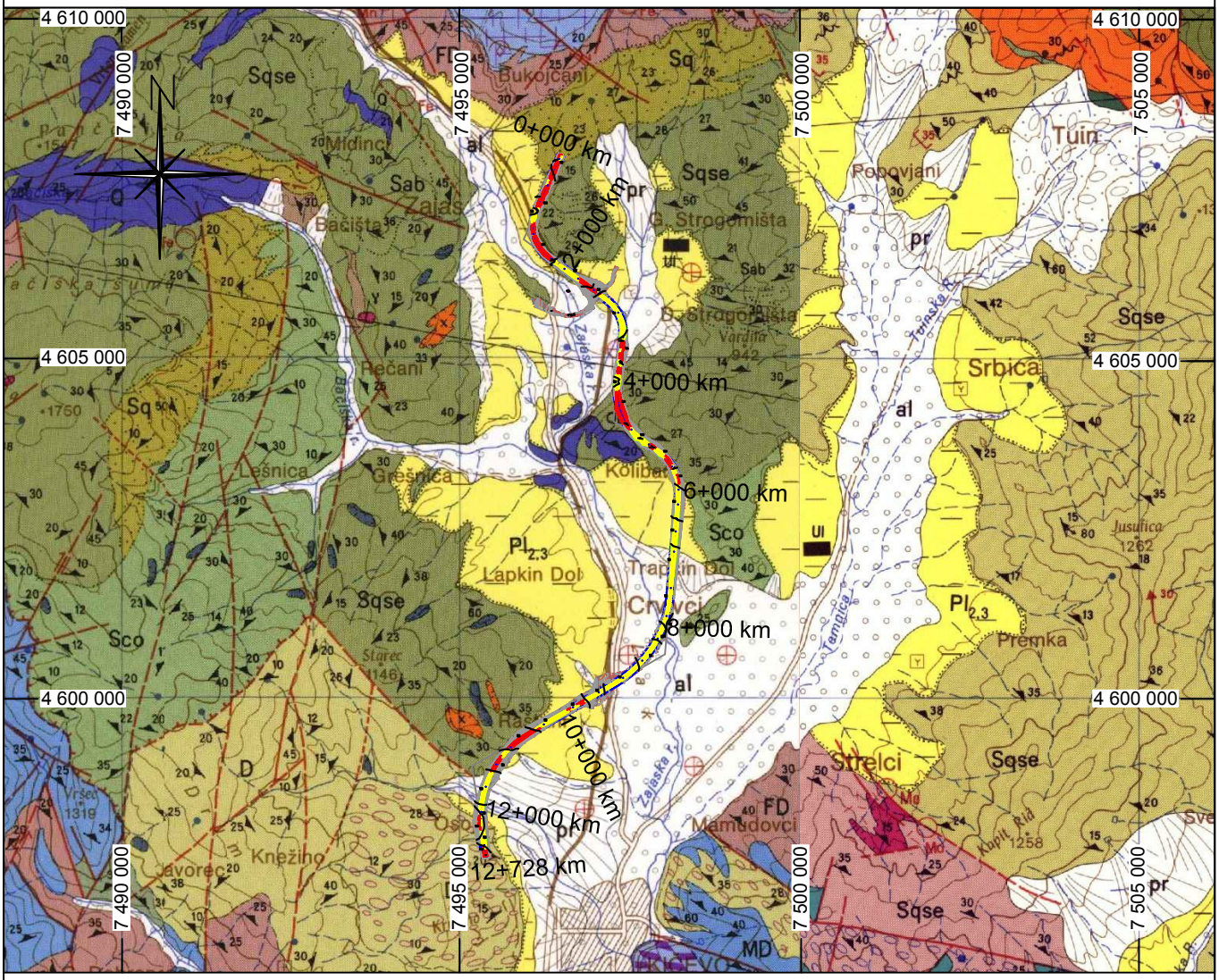
ultrabasic), and rarely of non-carbonate sediments. These soils received their name from their brown color and because they are formed under forest vegetation. On the surface there is usually up to 5 cm forest cover composed of dead organic residues, followed by 10-60 cm humus-accumulative horizon. The brown forest soils are soils of the moderate and cold humid climate that prevails in the forest areas, mainly in the area of beech wood forests. These soils are characterized by low content of clay which is the reason why they are water and air permeable and aerated, and are characterized by low waterproofing. The content of the humus varies between 2 – 10 % and it declines by depth. One of the main characteristics of these soils is the high active and potential acidity and low adsorbed base ions. The reaction is low acidic – pH and it ranges between 5,5 – 6. The largest part of these soils in forest areas are under forests, smaller part under meadows and pastures and smallest part under fields and fruit gardens.

- *Colluvial soil* – the colluvial soil is formed by deposition of torrential waters on sloping terrains (slopes with inclination of up to 25%) in the form of alluvial fans, with eventual occurrence of shallow groundwaters. These soils can be found along the foot of the mountains and the hills. The colluvial soils are a product of the powerful erosional processes in our mountainous and hilly terrains. Main factor for their formation is the human. They dominate in the areas with arid climate. The geological substrate is very important for their genesis. These are contemporary young soils in which the pedogenesis had no enough time to change the substrate. The vegetation of these soils is rapidly inhibited. The colluvial soils show great heterogeneity in their texture, as well as in the chemical properties and mineral composition. They usually contain 1-2 % of humus. Most of these soils are non-carbonate, with neutral to weak acid reaction. These soils contain small amount of nitrogen and small amount of nitrates and are suitable for fruit harvesting.
- *Fluvial soil -* The fluvial soil can be found in the fluvial terraces (covered with water or dry) and along the lake regions. These are contemporary (recent) river, lake and sea deposits with layers. Stratification often appears in these soils and some of the layers have no genetic connection with eachother, they are formed independently and in different time. The deeper they are the older they are. Unlike the alluvial soils, these soils are characterized by good gradation of the materials in the layers. In one layer there is no mix of particles with different dimensions. The color of these soils is highly heterogeneous and depends on the color of the deposits brought and accumulated by the river and it is usually: yellowish-grey, yellowish-brown, brown and grayish-brown. In the soils, the fraction of dust and fine sand is predominant. They usually have high porosity, they are well aerated, permeable, have medium waterproofing and low percentage of physiologically active humidity. The average content of humus in these soils in Macedonia is 2%. In the carbonate alluvial soils, the reaction is

neutral to weakly basic, while in the non-carbonate – neutral and rarely weakly acidic.

- *Cinnamon forest soil – (chromic cambisol) –* Main differential characteristic of this soil type is the presence of clayey cambic horizon which is combined in the solum with ochric or mollic horizon. The solum is without carbonate soil materials and it is eutric. It is composed of different sedimentary rocks, mainly non-carbonated, but also carbonated, as well as of different sedimentary rocks and their regolith, but over extremely acidic (quartz) rocks and clear limestones and dolomites. There is no well developed eluvial horizon. These soils are mainly composed under oak xerophilic and thermophilic vegetation and contain clay enriched and often compacted cambic horizon. These soils are mainly zonal i.e. related to certain bioclimatic conditions, the substrate and the relief has an important role in their formation. They are represented on different relief: wavy, hilly and pre-mountainous. These soils most often evolve into illimerized soils, passing through the transition phase of illimerized cinnamon soils. The depth of the profile is 50-100 cm which depends on the substrate, the age of the soil, the erosity and similar. These soils are considered well-drained and hot soils, without prolonged retention of the draining water in the soil mass. They are usually neutral, and occasionally weakly basic, the pH is oftenly above 6,5.
- *Wetland gleyed soil* – soils that have hydromorphic humus horizon shallower than 50 cm which is placed over the gleyed horizon. These soils can be found at the lowest terraces, in the negative forms of the relief where the groundwaters are shallow or additional strong moisturizing with the groundwaters. These soils are usually clayey and are characterized by poor permeability. They contain 2-10 % humus. The reaction could range from low acidic to low alkaline. Most often they show high absorptive capacity and high degree of saturation with bases. Generally, the chemical properties are favorable.
- *Anthropogenic soils (anthrosols) -* an anthrosol in the World Reference Base for Soil Resources (WRB) is a type of soil that has been formed or heavily modified due to long-term human activity, such as from irrigation, addition of organic waste or wet-field cultivation. This large group of soils includes two classes (agrogenic, technogenic). These soils are characterized by the appearance of different anthropogenic horizons or different anthropogenic soils materials within.

Геолошка карта за поширокатa област/
Geological map for wider area
M 1:100 000



Легенда / Legend:

Ново проектирана траса Букојчани-Кичево / Newly designed route Bukojchani-Kichevo

al	Алувиум / Alluvium	□	Кварцити / □uart□ite
pr	Пролувиум / Proluvium	S□	Кварцни метапесочници / □uart□metapodes
x	Риолити / Rioliths	Sab	Фелдспатизирани шкрилци / Feldspathesi□ed shales
$Pl_{2,3}$	Лапорци,глини,песоци и чакали / Marl,clay,sand and gravel	Sco	Зелени шкрилци / Green shales
□D	Кварцити / □uart□ite	S□	Метапесочници и алевролити / Metapodes and alevrolite
FD	Филитоиди / Phillitoids	S□se	Филитоиди / Phillitoids

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