KOSOVO QUARRY PLAN (KQP) – REVIEW, EVALUATION AND FUTURE DEMAND FOR CONSTRUCTION RAW MATERIALS IN KOSOVO

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Abstract

The Kosovo Quarry Plan contains an inventory of the complete surface-mineability construction mineral potential of over 80% of the Kosovo territory, an inventory of the existing exploitation sites, an estimate of the minerals demand for the next 10 years and recommendations for further development. The project created important prerequisites for the development of the aggregate mining and construction industry of Kosovo and the improvement of regional and local land use planning procedures and environmental protection as well. During data capture and verification, 904 construction mineral deposits / occurrences and 390 exploitation sites have been captured. The mineral deposits have been ranked with regard to their value and legal status, and a preference list of deposits for further exploration and / or exploitation has been compiled. Based on the evaluation results it can be said that Kosovo disposes of excellent potentials for the development of an extensive construction mineral industry by, for instance, quality silicate and carbonate aggregates, volcanic rocks, gravels, sands, and clays. The Kosovo Quarry Plan is an excellent tool for outlining potential mining sites and protection of deposits in the frame of spatial plans and mining industry development plans. The estimates on the future demand of construction raw material in Kosovo show that the demand for silicate and carbonate hard rocks as well as for clay will be covered by many times. In contrast, gravel and sand will have to be substituted by silicate and carbonate hard rocks by the end of the next decade. Finally, the results of the project have been summarised in a report and a set of thematic maps. The data is also provided in an easy-to-use database system, the GEO-Database Kosovo (GDK). The broader public can acquire base project information via the internet service: www.kosovo-mining.org.

Main Words

Construction Raw Materials, Non-Blocked Deposits, Mineability, Protection Value, Future Demand

Background

The Directorate of Mines and Minerals (DMM) – now the Independent Commission for Mines and Minerals of Kosovo (ICMM) – contracted the project "The Compilation of the Kosovo Quarry Plan" to Beak Consultants GmbH. During the first project stage, which was executed between 8th November 2004 and 30th June 2005, all available geological and economic data with regard to construction minerals (i.e. material which is suitable for the production of aggregates, dimension stones, bricks, roof tiles, cement, asphalt etc.) has been collected and evaluated. In the first and second

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project stage, this data was verified in the field and additional data of mineral deposits / occurrences, mining licences (until 30th September 2005) and exploitation sites (until 31st December 2005) was captured. This included the determination of their shape, geographical position, legal status, state of geological knowledge, resources, usability for construction purposes and quality. The second project stage, which started 1st July 2005, was finalised in March 2006. During this stage, a land wide uniform deposit evaluation procedure was developed. Based on it, all non-blocked construction mineral deposits / occurrences have been evaluated concerning their mineabilty and concerning their protection value. The final report "The Kosovo Quarry Plan – Review, Evaluation and Future Demand for Construction Raw Materials in Kosovo" contains an inventory and ranking of the non-metallic minerals of over 80 % of the Kosovo territory with main focus on aggregates and construction materials. The results are also presented in a set of five thematic maps at a scale of 1 : 50,000 covering whole Kosovo. Furthermore, the report contains an inventory of the past and actual mining activities, an inventory of the existing exploitation sites, an estimate of the construction minerals demand for the next 10 years and recommendations for further development.

Data Collection

During fieldwork, raw material base data of 904 construction mineral deposits and occurrences was captured (until end of September 2005). This includes 358 silicate hard rock, 385 carbonate hard rock, 109 sand and gravel, 52 clay, bentonite and kaolin deposits and occurrences. In addition, data on 390 exploitation sites was captured during the project execution. Excavation activities were visible at approximately 170 exploitation sites at the time of the field visit (captured until end of 2005). Based on the results of the field data capture it can be said that Kosovo disposes of excellent potentials for the development of an extensive construction material industry by, for instance, high quality silicate and carbonate aggregates, volcanic rocks, (quartz) sands, and clays. Alluvial sand and gravel deposits are mainly used as concrete add-on and mostly do not have a large spatial extent.

Evaluation and Ranking of Deposits

Overview

Based on the existing legislation, a methodology was developed that consists of the following core elements:

- The selection of non-blocked parts of mineral deposits and occurrences,
- The evaluation of the non-blocked deposits (Definition of potential mining areas, evaluation of them),
- The ranking of the deposits according to their mineability value and legal status (Definition of future potential mining assets),
- The recommendations for long-term deposit preservation.

The main methodological steps of the selection, evaluation and ranking of the deposit are shown in Figure 1. In the first step, all non-blocked (that means: not situated within settlements, roads, rivers etc.) deposits were selected based on the available primary data. Therefore, catalogues of blocking, limiting and filter criteria have been used. After their application, the raw non-blocked raw material deposits were reshaped and reattributed; while for mining unsuitable stripes were removed. The result is the raw material base data, used for the deposit evaluation. The second step can be subdivided into the evaluation of mineability, the evaluation of legal status, and evaluation of the deposit protection value. Every non-blocked deposit was characterised by a value of mineability and deposit protection, which was

influenced by the following seven parameters: legal status, deposit's thickness, stripping ratio, geological reserves, knowledge, quality and connection to the main infrastructural network. Criteria catalogues (consisting of parameters and their scoring) were created for every single evaluation procedure. Finally, in the third step, all non-blocked deposits were ranked concerning their mineability and deposits protection. The evaluation approach and the results are described in-depth within KQP report [1].

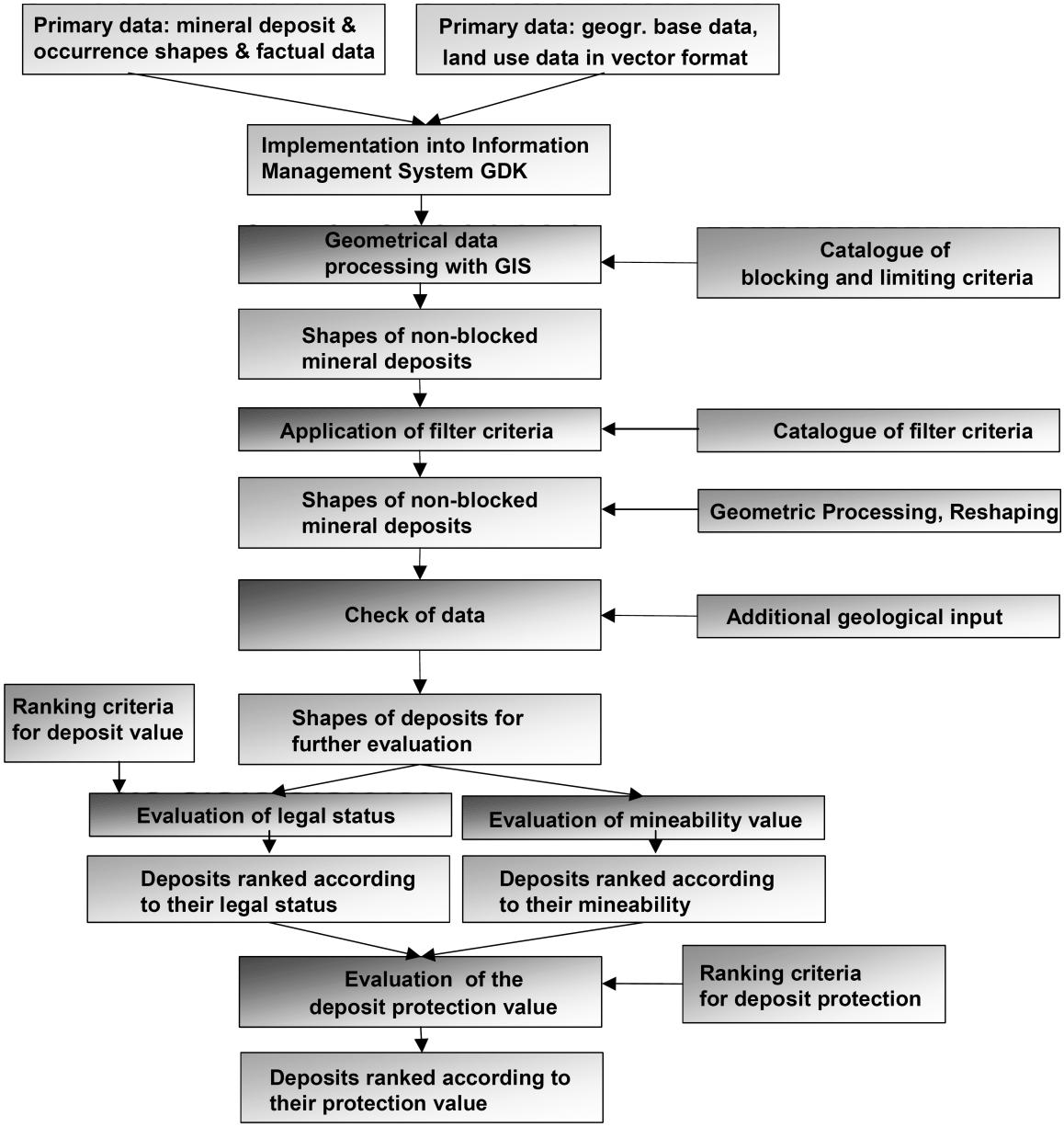

Figure 1: ***Overview about the Deposit Evaluation / Ranking Processing Steps.***

Preparation of Base Data

The raw material base data was compiled in a way that ensured a direct and easy ranking procedure. Because of this, there was no need to change or manipulate mineral occurrence and deposit data. In contrast, the compilation and

adaptation of topographic data required much work. Because of the obvious discrepancy of topographical items between topographical maps and aerial images, the roads, airports, settlements, rivers, lakes, industrial zones, waste dumps, military constructions, power plants and electrical substations were digitised from the aerial images: Finally, all data was merged into one file, which was used a basis for the buffering procedure. Added attributes (metadata) ensured the linkage between spatial and factual data. After the finalisation of the base data capture and preparation, it was presented on the "*Base Map of Deposits of Construction Materials*".

Definition of Non-Blocked Deposits

The overall aim of the KQP was to segregate potential mining areas, which minimise environmental impact, especially impact on the affected population, on areas of infrastructural importance and on areas of designated landscape, nature conservation or heritage value. Because of this, criteria have been defined to minimise adverse effects such as local disruption of the community, breakdown of existing infrastructure and destruction of riverbeds. On the one hand, these criteria ensure the conservation of minerals as far as possible, whilst also ensuring an adequate supply to meet needs. On the other hand, they prevent unnecessary blocking (sterilisation) of mineral resources by surface development. Blocking criteria, i.e. criteria sterilising mineral resources by existing infrastructure or important nature conservation or heritage value, are not in every case clearly and explicitly outlined in the existing legislation. Adaptations, assumptions and further explanations were required to develop a guideline for the application in the KQP. The definition of the blocking criteria takes into consideration the status of mining as well as other land use purposes. Therefore, the definition of blocking criteria is orientated to applicable law (mining law, water law) but does not copy the relevant items directly. The aim of the KQP was not to anticipate the licence procedure, but rather to evaluate and summarise the most important construction mineral sources of Kosovo. In the KQP report, all blocking criteria and their minimum distance to the next quarry or mine are listed. They have been compiled mainly by usage of the mining law, section 12 [2]. Limiting criteria are non-blocking criteria. They are understood as areas of land-usage, where mining could be prohibited and a mining licence could be refused.

The selection of non-blocked deposits in the proper sense is a mathematical act, based on computerised geometrical operations. First, all data, which was concerned as blocking criteria, was collected and implemented into the GIS in vector format. Every single item got assigned a blocking distance – this is the value within which no mining is allowed because other land use items are considered as more important than mining. The single blocking criteria were buffered with this value. Second, the shapes of all captured deposits were entered into the GIS: All deposits, which are connected to an active mining licence, were not buffered independent of their geographic position. The issue of a mining licence is considered as legal act, which implements a measuring of all interests / conflicts. That is why all these areas were extracted and after the buffering process added to the non-blocked deposits. The intersection of blocking criteria and deposits / occurrences resulted in the raw data of the non-blocked deposits / occurrences. After reshaping, regrouping and removal of too small areas, the "*Map of Non-Blocked Deposits of Construction Materials*" was created.

Evaluation of Mineability

The evaluation of the deposits mineability forms the basis for the ranking of the deposits. The evaluation was executed separately for every commodity group. The following six parameters were used for the evaluation of the deposits mineability: thickness, stripping ratio, geological reserves, knowledge (according to UNCF-classification [3]), quality

and infrastructural connection. During deposit evaluation, scores for each of the parameters were assigned to each deposit. The higher the score, the higher the deposit mineability. The highest assigned score is 5 points; the lowest possible score is 1 point.

The average thickness has been estimated for every deposit / occurrence. If only a range was estimated during field capture, the arithmetic mean was calculated and used. This parameter describes the real height of a deposit and not only the part which can be exploited. As maximum value, the thickness is delimited to 70 metres because mining of construction minerals seldom occurs in greater depths. The higher the thickness, the higher the deposit value, since the specific reserves are increasing per used area unit. The stripping ratio was calculated through the division of the deposit thickness (in m) by the overburden thickness (also in m). An increasing stripping ratio results in lower costs for surface mining. The higher the stripping ratio, the higher the deposit value. The geological reserves were calculated by the multiplication of the deposit's area (horizontal projection of the deposit, calculated by GIS) and the average thickness. The real mineability reserves were not utilised because they do not exist for most deposits, especially for deposits with a low status of knowledge and not yet mined deposits. The higher the reserves, the higher the deposits value. The status of knowledge is of major importance to assess a deposit. The UNCF classification scheme was used to characterise the status of knowledge of every deposit. An increasing status of knowledge resulted in a higher value of the deposit. The estimation of the deposit quality was crucially influenced by two parameters: the potential / current usage of the material and quality parameters such as gravel content, crushing strength or Los Angeles coefficient. For the evaluation of the usage, the highest possible scoring value was assigned. The connection of a deposit to potential markets is also an item, which plays a important part in determining its value. An increasing distance to main roads results in greater obstacles to access main markets and higher costs for developing the quarry. The beeline distance to the next main road was measured for every non-blocked deposit / occurrence. The shorter the distance to the main road, the higher the deposit value.

Not every parameter is of equal importance to determine the value of mineability of a deposit. This is why every parameter was directly compared to all other parameters resulting in weighting factors where a parameters gets a score of one weighting point if it is more important compared to the other. Altogether, 18 weighting points were assigned. The sum of all weights had to be 1. The developed weighting formula for estimation of mineability is:

mineability = 0.1*thickness + 0.06*stripping ration + 0.28 * reserves + 0.22*knowledge + 0.28*quality + 0.06*infrastructural connection

The result was a deposit mineability value between 1 and 5. Following this, a further statistical analysis was done to form four classes of mineability. Of every commodity group, approx. 15 % of all deposits was considered as being of the highest mineability class (class 4). Another 3 classes with an increasing amount of deposits were added. Here, equal class widths have been chosen. This was separately done for all four commodity groups. The resulting four classes have been visualised in the "*Map of Mineability*".

Evaluation of Deposits Protection Value

The deposit protection value was also divided into four classes like the mineabilty to ensure the comparability. All active construction mineral exploitation licences with known coordinates (printed on the "*Map of Legal Status*") got

assigned the highest deposit protection value of 4 points and were ranked to the highest class of deposit protection value (class 4). A licence was considered as active, when its assigned status within the GDK was: "Approved by Board" or "Current" at 30th September 2005. In all other cases, the deposit protection value is equivalent to the mineability value. The deposit protection value has been visualised in the "*Map of Deposit Protection Value*".

Results

The Kosovo Quarry Plan is an excellent base for outlining potential mining sites, and protection of deposits in the frame of spatial plans and mining industry development plans. Based on the results of deposits evaluation and ranking, Kosovo disposes of 1,165 non-blocked construction mineral deposits / occurrences. Among these, 189 are of the highest mineability class 4 (16.2 %), see Table 1.

Table 1: Construction Mineral Deposits of Highest Deposit Mineability Class.

Commodity Group	Number of Deposits	Geological Reserves (Mio. m³)	Area (km²)
Silicate Hard Rocks	77	5,292.0	81.2
Carbonate Hard Rocks	66	4,771.8	79.0
Gravel and Sand	29	128.3	30.0
Clay, Kaolin, Bentonite	17	445.1	13.8
SUM:	**189**	**10,637.2**	**204.0**

The highest deposit protection value class 4 could be ascertained for 258 deposits / occurrences (22.1 %), see Table 2.

Table 2: Construction Mineral Deposits of Highest Deposit Protection Value Class.

Commodity Group	Number of Deposits	Geological Reserves (Mio. m³)	Area (km²)
Silicate Hard Rocks	78	5,292.2	81.2
Carbonate Hard Rocks	109	4,825.0	80.9
Gravel and Sand	52	129.4	30.3
Clay, Kaolin, Bentonite	19	447.1	13.9
SUM:	**258**	**10,693.7**	**206.3**

The following Table 3 lists the estimated demands for construction minerals for the next ten years, which are shown in relation to the maximum reserves of deposits with the highest protection value (highest class). Despite the fact that available geological reserves can only be exploited in low percentage, the estimated demand for silicate and carbonate hard rocks as well as for clay in Kosovo will be covered by many times that amount. Concerning the further use of gravel and sand it has to be stated that by the end of the next decade these will have to be substituted by silicate and carbonate hard rocks. Furthermore it could be shown that the regional provision of high valued deposits can be guaranteed for all five regions: Mitrovicë / Mitrovica, Prishtinë / Priština, Pejë / Peć, Gjilan / Gnjilane and Prizren. Despite the fact that available construction mineral resources in Kosovo can cover the estimated demand for more than

the next 1000 years, it is obvious that the regional distribution of rocks does not fit with the estimated regional demand. Only about 19 % of all estimated geological reserves of aggregates and hard rocks are located within the Prishtinë / Priština region, where about one third of all Kosovars live, where major investments will be made in future and where larger infrastructural projects are already planned. Therefore, it will be very important to define mineral protection areas first in those regions with high anthropogenic pressure like in the Prishtinë / Priština region.

Table 3: Estimated Construction Mineral Demand of Kosovo for the Next Ten Years.

Commodity Group	Demand until 2015 [thousand tonnes]	Geological Reserves of Deposits with highest Protection Value Class [thousand tonnes]
Silicate Hard Rocks	50,000	14,289,000
Carbonate Hard Rocks	90,000	13,510,000
Gravel and Sand	70,000	233,000
Clay, Kaolin, Bentonite	20,000	939,000

According to the exploitation licences issued, the estimated percentage of silicate hard rocks used as ballast, grit etc. and as dimension stones is much less than that of carbonate hard rocks and less than that of gravel and sand. Because of the growing need for better quality and abrasion-resistant aggregates, the percentage of demand for silicate hard rocks is estimated to be about 25 %. More than the half of the silicate hard rocks is estimated to be mined as high quality crushed rock (35 million tonnes). The low quality serpentinite, which is currently mined in large amounts, will not be accepted as road construction material in accordance with European standards. The estimated geological reserves of silicate hard rocks with the highest protection value are about 14,289 million tonnes. Considering the fact that only ten percent of these reserves can be used for the foreseen purposes, there will be enough silicate hard rocks for the next 285 years. Nevertheless, it has to be mentioned that, at present, the licensed deposits (approved and active licences) do not cover the estimated demand for (higher quality) silicate hard rocks for the next 10 years. For the time being, carbonate hard rocks can substitute some demand, but relevant measures will have to be taken in the short to medium term.

It is estimated that about 45 % of mined primary aggregates are carbonate hard rocks. The larger annual demand for carbonate hard rocks is based on the assumptions that the demand for aggregates will grow from 2007 on because of the construction start of some larger infrastructure projects and the continuing preferred mining of carbonate rocks. The estimated geological reserves of carbonate hard rocks with the highest protection value are about 13,510 million tonnes. Considering the fact that only one quarter of these reserves can be used for the foreseen purposes, there will be enough carbonate hard rocks for the next 375 years.

About one third of mined primary aggregates are estimated to be gravel and sand. The estimated geological reserves of gravel and sand with the highest protection value are about 233 million tonnes. Because of some differences between aggregate and hard rock deposit geometry and exploration techniques, more than 60 percent of the estimated reserves seem to be mineable in practice. Considering this fact, the available reserves will only last for about 20 years. At the end of the next decade, gravel and sand deposits will therefore have to be substituted by silicate and carbonate hard rocks.

The estimated geological reserves of clay, bentonite and kaolin with the highest protection value are about 939 million tonnes. When proceeding with the assumption that about two thirds of the estimated reserves can be used for brickmaking and other relevant purposes, the available reserves will last for the next 300 years.

Conclusions

The KQP presents a comprehensive inventory of the construction raw materials of Kosovo. All non-blocked deposits were evaluated and assessed to identify the most prospective and worth of protection deposits. Together with the construction minerals demand analysis, a strategy for Kosovo's construction mineral supply can be given for the frame of one decade. The KQP summarises all relevant available data on construction minerals, the construction mineral demand and base planning data. Notwithstanding the fact that the status of geological knowledge varies strongly, the report provides an excellent base for further studies and especially for the orientation of the responsible state authorities and the construction raw material mining industry.

Within the frame of the project, construction minerals of high quality and mineability were identified as follows:

- Within the group of silicate hard rocks, gabbros and ophiolitic rocks were identified as high quality aggregates. They meet the requirements for the production of railroad ballast. Well suited for engineering construction purposes are fine grained gneisses, as well as andesites and quartzites. At the moment, these rock types are only mined in a limited amount.
- Recrystallised limestones and marbles are also a source of high quality aggregates. Currently, they are of fundamental importance for the aggregate supply of Kosovo. Besides cement production, carbonate hard rocks can be of further usage in the production of quicklime and the chemical industry, but currently the material is seldom used for these purposes.
- Material from alluvial sand and gravel deposits is mainly used as concrete add-on. Beside some Pliocene sands, which can be utilised for the production of lime silica bricks, high quality sand and gravel deposits do not exist. Furthermore, the gravel deposits are of low thickness and size and often blocked by other land use purposes.
- Pliocene clay occurs widespread and in large deposits. Currently, the material is used only for brickmaking. Potentially, these clays can also be used for the production of roof and floor tiles and as landfill sealing material. Clays for special purposes (refractory, porcelain, filler and colour production etc.) occur subordinated in the eastern part of Kosovo.

The recognised blocking of deposits through housing and trading constructions is a serious problem, which can lead to obstacles in developing and supporting Kosovo's construction minerals industry. Some important deposits (for instance the onyx travertine near Banje e Pejës / Pečka Banja) are already blocked. The implementation of the KQP results into spatial plans and regional development plans is of major importance.

Kosovo disposes of enough high class construction minerals to ensure that demands are satisfied for the next decade. Many deposits with perspective interesting usages (for instance decorative and dimension stones, fine ceramics, refractory and chemical industry) were identified and described. But, their potential is currently not exhausted, and the usage is mainly limited to the production of simple products like bricks and aggregates. Measurements are necessary to reduce Kosovo's dependence on imports of decorative stones, floor tiles and other high class construction material.

Exploitation of construction raw materials takes place nearly everywhere across the country. The quality of the exploited material varies strongly. High quality aggregates are mainly exploited in larger quarries by blasting. Smaller, non-licensed operations often mine partly unsuitable material using only excavators and lorries.

Besides the fact that there are enough reserves of silicate hard rock, limestone and clay to cover the demand of Kosovo for a long time it has to be mentioned, that there are strong gaps between reserves of licensed operations and the demand for silicate hard rock, clay and gravel. Merely the amount of licensed limestone covers the estimated demand. Gravel and sand has to be substituted by silicate or carbonate hard rocks in any case within the near future.

Because of strong construction activities in Kosovo and the (potentially) growing demand in the neighbouring countries, the development of the construction mineral industry can have an important initial effect on the economy of Kosovo as a whole. The KQP project will contribute to the attraction of investors and the protection of high quality construction mineral resources against any kind of sterilisation or blocking by other land uses.

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