

## **7. Analysis of Industry and Structure of Industrial Production in FBiH for Non-Metals**

### **7.1 Cross-Section Data of the State**

For a long time one was of the opinion that metallic and energy mineral raw materials are the only useful natural mineral resources or, in short: ores. Only few people believed that rocks are as important as ores and, in some cases, even more important than ores or coals. That is probably the reason why we cannot boast with an industrial development based on non-metallic mineral raw materials.

We have been dealing with non-metals intensively only since the eighties of the past century, and those were mainly of the kind that was used for the production of construction materials.

A scientific approach to geological researches gradually widened the perspective for understanding of non-metals and their application which suppressed the incidental "digging up at the borrow pits" of rocks.

Advantages in the research and understanding of non-metals when compared to other mineral resources is reflected in the fact that they do not last long, they do not demand large financial investments, the mineral substance is used as a whole, unlike metallic substances, for which, in most cases, a useful mineral raw material has to be separated from the ore-residue.

Today there are around 52 industrially accepted, non-metallic mineral raw materials in the world, while in Bosnia and Herzegovina this number is significantly lower, although the geological conditions enable a much larger number.

An increased interest for researches and the exploitation of non-metallic mineral raw materials (nmrm) was particularly expressed following WWII. At first, the geological researches were limited to magnesites and certain construction materials, among which the most significant were: brick and ceramic clay, limestone and dolomite, gypsum, baryte, sand, and other mineral raw materials. These are raw materials which would be, in Bosnia and Herzegovina, the basis for the installed capacities: „Vatrostalne" in Zenica, ferrous metallurgy, also in Zenica, and Cementara in Kakanj.

The geological researches were, at that time, often simultaneously followed by exploitation, which also caused more frequent changes in the production plans,

assessments in the amount of resources in an area and similar mistakes. That says enough about the equipment which was at disposal at the time so that the materials were transported from the highland terrains in pack saddles, village carts or disused military trucks. In order to create a complete picture of the situation we should add the large lack of expert staff.

### **7.1.1 The State of Non-Metals and Construction Materials until 1992**

More intensive geological researches, after the gathering and training of a larger number of expert staff, and the procurement of the necessary equipment, resulted in new sites, of already known, but also new non-metallic raw materials. The clusters of information on new mineral raw materials grew daily, which enabled the switch with already known combinations, or gave space for newer, better combinations. In this way the raw materials basis was created, which was used for the organization of production in over 150 basic organizations, the organization of joint work, or different firms, out of which there was nearly 100 firms using only construction materials.

There were already around 20 non-metallic mineral raw materials identified, employing around 15,000 workers for its production.

The main consumers of non-metallic mineral raw materials were:

- the construction industry (limestone, dolomite, gypsum, marble, magmatic rocks),
- ferrous metallurgy (limestone, fluorites),
- the chemical industry (limestone, salt water, and other),
- the cement industry (limestone, marl, clay, gypsum),
- the refractory industry (magnesite, ceramic and refractory clay),
- the glass industry (silica sand, dolomite, limestone),
- the ferrosilicon industry (silica, quartzite),
- sugar factories, agriculture (limestone, pyrophyllite)

What should also be added are the started, and partially realized, industrial capacities based on identified nrm, such as chrysotile asbestos, in the village Bosansko Petrovo, the gypsum factory in Donji Vakuf, the installed separation plant of kaolin in Bosanski Kobaš, the factory of electroceramic products in Tešanj, and we get a complete picture of the state of identification, nature, and application of a large part of non-metals as well as the industrial capacities for their processing.

### **7.1.2 Annual Production per Amounts and Supplies of Non-Metals and Construction Materials**

According to the incomplete data of the selected 18 non-metallic mineral raw materials and construction materials, annual production was approximately in the scope given in Table 7.1. The fact that the data is incomplete is caused by many reasons: not keeping registry books on mineral raw materials, and the non-provision of data to the competent

Ministry in the prescribed deadline, the untimely informing on the end of exploitation at a certain site or failing to resume work in the period after the war, the division of resources between entities, and other unresolved problems of an organizational and administrative nature. In some cases, after the signing of the Dayton Peace Accord, the location of the mineral raw material belonged to one entity, and the installed industrial capacities belonged to the other entity.

**Table 7.1** The annual production of NMRM, and NMRM supplies

No.	Name of the site and company	Produced in 1990 in 000 t/m <sup>3</sup>	SUPPLIES	
			Balance reserves	Potential reserves C <sub>2</sub> category
			A+B+C <sub>1</sub>	
1.	BARYTE	11	90	126
2.	BENTONITE	-	-	-
3.	WHITE BAUXITE	-	-	2,000
4.	CEMENT MARL	- VK - 1	7,568	-
		- NK - 1	3,017	-
		- NK - 1	346	-
5.	DOLOMITE (39 sites)	1,319	96,904	53,448
6.	FLUORITE –Kreševo	-	-	-
7.	GYPSUM (7 sites)	386	22,184	34,295
8.	ROCK SALT – Tuzla	-	342,000	-
9.	CER. REFRACTORY CLAY	-	9,323	12,880
10.	LIMESTONE (33 sites)	3,425	151,230	39,796
11.	CHALK			
12.	QUARTZ SAND			
13.	QUARTZITES (7 sites)	30	3,237	2,789
14.	MAGNESITE Konjuh	40	1,647	2,443
15.	BRICK CLAY (5 sites)	341	18,541	5,553
16.	PYROPHYLLITE (Konjic)	60	27,000	4,991
17.	POZZOLANA (tuff)	-	-	-
18.	TECHN, CONSTR. STONE I	10	9,555	4,281
19.	DECORATION STONE –Gabro	60	11,201	-

The presented information refers to the non-metallic mineral raw materials which belong to the Federation of Bosnia and Herzegovina. There are some new among those raw materials (some sites of quartzite, limestone, and dolomite). All the others belong to a group of sites researched and opened for exploitation long ago. The sites belonging to the other entity were also left out.

### 7.1.3 Non-Metallic Mineral Raw Materials Today

The selected 18 nmr represent just what the Federation of BiH has at its disposal: information on production, balance, and potential amounts (Table 7.1) of non-metals.

They are at different levels of research.

### **Baryte**

Sites of baryte are concentrated mainly in the Paleozoic mountains of North-West, Central, and South-East Bosnia. After WWII, geological researches and the exploitation of baryte were intensively conducted in the area of North-West Bosnia, especially in the areas around V. Kladuša, Bosanski Novi, Ljubija, and Sanski Most, in North-West Bosnia, in the wider surroundings of Fojnica, Kreševo, Kiseljak, Tarčin, Gornji Vakuf, and Novi Travnik, in Central Bosnia, and in Prača, and Foča, in South-East Bosnia.

Immediately before the aggression on BiH, there were 9 baryte mines on that area from the beginning of 1946 to 1968, of which only two remained: **Baryte mines Kreševo** and **"Bosnabarit"** at Velika Kladuša.

After the last war no mine has restored production, so that Bosnia practically has no baryte exploitation.

### **Bentonite**

Bentonite clay is mostly composed of montmorillonite, a mineral which is the product of the decomposition of magma rocks or the devitrification of glass expelled in volcanic eruptions.

A characteristic of bentonite clays from Bosnia is that they are mainly monomineral with a content of over 95% of montmorillonite.

Clay sites in the Federation of BiH were discovered around Tešanj: Raduša, Žabljak, and Trepča. The geological and mining research works established that these are minor bodies dominantly made up of montmorillonite. Similar sites are located in Džamba, Kulići, and Stražba at Gračanica, closer to the road and railroad tracks between Tuzla and Doboj.

The application of bentonite is diverse, beginning from the distillation of oil and oil derivatives, the creation of drill-in fluids at deep drills in the exploitation of oil, the fat industry, perfume oils, the distillation of drinking water, the protection of plants in forest fires, the enhancement of soil quality, the paint and lacquer industry, paper, rubber, plastic, ceramic and glass industry, and in construction engineering for the erection of dams and soil injections.

### **White bauxite**

Basically, white bauxite is not chemically different from red bauxite in which  $\text{Fe}_2\text{O}_3$  is present more clearly, so that white bauxite can be considered a product of whitening of red bauxites, which is the reason they are found together.

Economically, the most significant sites of white bauxite are concentrated in the layers of the Grmeč Mountain, in two stratigraphic levels. The total share of white bauxite of 3,000,000 (2,912,000 tons), C<sub>2</sub> - category, with a contents of  $\text{Fe}_2\text{O}_3$  below 10%,

seems to be a good foundation for further research and studies, especially because there are also 24.6 millions of tons of red bauxite with a contents of  $\text{Al}_2\text{O}_3$  of around 65% in the same sites of the bauxite area.

White bauxite is interesting in the production of refractory materials and more quality cement, so the application conditions are also different.

### **Cement marl**

This name marks the types of marl, rocks which are appropriate for cement production, which in a specific case means that the chemical composition has a favorable content of basic  $\text{CaO}$ ,  $\text{SiO}_2$ ,  $\text{Fe}_2\text{O}_3$ , and  $\text{Al}_2\text{O}_3$ , and a lowest possible content of  $\text{K}_2\text{O}$ ,  $\text{MgO}$ ,  $\text{Na}_2\text{O}$ , and  $\text{SO}_3$ , as harmful components.

Besides their chemical composition, attention was also paid to the location of the marls during the research. They had to belong to high overlying sediments of coal layers: Banovići, Sarajevo – Zenica, and Miljevina coal basin, where the researches were also conducted. In that respect, a series of marls and coal marls was rated, 47 meters thick in the overlying sediment of the main coal layer at the location Greben near Kakanj.

A combination of the low component (Lc - 1 and Lc - g) of 20% and the high component (Hc - 1) of 80% makes quality "flour" for the production of portland cement clinker in the production of cement at the factory in Kakanj.

### **Dolomite**

A monomineral carbon rock composed of dolomite minerals. Chemically pure dolomite contains 30.41%  $\text{CaO}$ , 21.86%  $\text{MgO}$ , and 47.83%  $\text{CO}_2$ . Additives in dolomite can be: calcite, magnesite, siderite, opal, chalcedony, clay minerals, gypsum, silica, and other minerals.

Although dolomites have a wide spectrum of application: refractory materials industry, as melting agents in ferrous metallurgy, in the production of glass, cement, paper, paints and lacquer, rubber, and in pharmaceutical and ceramic industry, and it was exploited in the Federation of BiH at 33 sites and used as technical and construction stone for the making of concrete and concrete accessories. Almost all of the sites are privately owned.

Fluorite (from Latin: to flow, flowing) fluorite is an important mineral for the production of fluorine. The chemical composition of  $\text{CaF}_2$  contains: 51.22% of Ca and 48.78% of F, if it does not contain additives.

It can be found in crystal forms in lodes, but also in individual flaky, clustered, and large-grained aggregates or even in earth masses. Registered occurrences in the Federation of BiH probably belong to a hydro-thermal type of creation. The barite - fluorite lode of hydro-thermal origin was discovered at the site Žune, between Islam Ljubija and the village Šurkovci, in the area between Prijedor and Ljubija.

Earth masses of fluorite at the area of Meovršje near Kreševo were at the time excavated for the needs of the iron factory in Zenica.

Fluorite is usually applied in ferrous metallurgy, chemical, glass, ceramic, and cement industry and optics, under certain conditions, of course.

### **Gypsum and anhydrite**

They belong to the sediments formed by crystallization from sea water, so they usually contain many types of sea salt, certain types of dolomite and limestone.

The largest masses of gypsum and anhydrite are concentrated in the Una-Sana Canton, in the upper stream of the Vrbas and Neretva rivers, and in the basin of the Kolunska River, the left tributary of the Drina River.

The exploitation of gypsum is conducted at the sites Brešćić (Kulen Vakuf), Bistrica (Gornji Vakuf), in Elezovići I, II, III, at Donji Vakuf, while researches were conducted in Sovići near Jablanica, and in Presjeci near Ustikolina.

Gypsum is basically a raw material which must contain 70%  $\text{CaSO}_4$  and  $2\text{H}_2\text{O}$  at the site, with a minimum content of additives, such as the types of gypsum present in our area.

Gypsum is widely applied in cement, construction, chemical, and glass industry, then in paper production, in plastic arts for the casting of moulds, in surgery for the production of bandages, in agriculture, and in other fields of application.

### **Rock salt (halite)**

Salt sites in the Tuzla basin belong to the so-called „strip layer“ which lies on a “red layer” and the overlying sediment with the salt deposits is made up of the so-called „marine siltstone“. These are all different types of rocks comprised into one whole which contains bodies of salt, at the newly explored site in Tetima, a village north-east of Tuzla.

Besides salt, the strip layer also contains marls, gypsum, anhydrite, thenardite, glauconite, and limestone.

The exploitations of salt at the sites: Trnovac, Hukalo, and Tušanj are completed, and the Tetima site has been opened, with a confirmed amount of 342,000,000 tons, with a content of NaCl of 93.75% and 5.64% of indissoluble residues. The thickness of the salt at the site varies from 150 to 180 m.

Besides the usage of table salt in food, it is also largely used in the leather, and chemical industry, as well as in other branches of industry.

### **Ceramic and refractory clays**

They are comprised of finely dispersed particles (below 2 microns) of various mineral and chemical compositions. The main chemical components of clays are:  $\text{SiO}_2$ ,  $\text{Al}_2\text{O}_3$ , and  $\text{H}_2\text{O}$ , while the hazardous components are:  $\text{Na}_2\text{O}$ ,  $\text{CaO}$ ,  $\text{MgO}$ , and the oxides Fe and Mn.

Research and exploitation of clays in the Sarajevo – Zenica neogenic basin was conducted at the south-west border of the basin, approximately at the direction of Sarajevo - Kiseljak - Busovača - Travnik. Besides the exploitation of clays at the site Golo Brdo near Visoko (IGM), exploitation at other locations has not been restored following the end of the war.

Clays of the Sana neogenic basin (Kruhari and Demiševci) are exploited from time to time, just like the site in the Cazin neogenic basin (Čoralići).

It is important to check the qualitative features of ceramic and refractory clays before application, since they vary from site to site. However, for clays from our area, it can be highlighted that they generally belong to a class of low to medium refractory clays, while the high refractory clays (over 40  $\text{Al}_2\text{O}_3$ ) can be extracted with more difficulty.

### **Limestone**

Carbonate rocks comprised mostly from carbon fractions, in which calcite is the dominant ingredient. Besides calcite, the following allothigenetic minerals can occur as important ingredients: quartzite, feldspar, gypsum, chalcedony, opal, glauconite, limonite, pyrite, and others which were formed at the time, or after the sedimentation of limestone.

Limestones, by their physical, mechanical, and petrologic properties mostly meet the conditions of the construction industry, and they are therefore mostly exploited for that use. At the area of the Federation of BiH, 33 sites are exploited. Only a few of them were used for the needs of ferrous metallurgy (Ševarlije - Dobož and Stijene - Vareš), chemical industry (Vijenac - Lukavac), the production of sugar (Jošanica - Zvornik). In all other cases, limestone is used for the needs of the construction industry in the production of concrete and concrete accessories. The leading manufacturer in that respect is "INGRAM" - Srebrenik.

### **Chalk**

White, soft, porous rock, comprised of shells of microorganisms, mostly foraminifers and microcrystal calcite, is called **chalk**, or in this specific case lake chalk, which can be found at the location of Gorica near Bugojno. Partial research and test exploitations were conducted earlier by the Gypsum mine from Donji Vakuf. The gained results point to the need for further researches, and the identification of the amount and quality of the raw material.

### **Quartz sand**

It is composed of grains of quartz of different shapes and sizes. They can be found in a loose or weakly bound state. Depending on the fact of whether the used material is deposited at the place of creation or whether it is transported by one of the natural transporting means into another geological surrounding, we differentiate between: eluvial, alluvial, eolic, lake, and marine sands. The sand from the Tuzla neogenic basin

(Miladije, Moluhe, Bukinje, and others) belongs to the marine and lake sands, with a thickness of 30 to 100 m, just like the sands from the Sana neogenic basin (Majkići).

Besides the fact that quartz sands are the basic raw material for the production of glass, they are also used in the metal casting industry (moulds), as well as in the ceramics industry (Dinas stone).

A conclusion was reached, following detailed research and test exploitation of the Tuzla basin, that sands there could be used in the production of siporex.

### **Quartzite**

Quartzites are metamorphic rocks, created by contact and regional metamorphosis, and so we find them in various geological surroundings. The largest number of sites is registered in the Central Bosnia shaly mountains, in the wider area of Gornji Vakuf (Smrčevica, Gradac, Gomilica, Obod, Zapad, Marijine stijene, Kljun, and Lazine), Fojnica (Visočica, Motorac, and other locations), and in the area of south-east Bosnia (Renovica, Mostine, and Trebeško brdo).

In the period after the war, geological research and exploitation of quartzite at Smrčevica (Vranica Mountain) was activated by the newly formed company Rudnici kvarcita "Smrčevica" - Gornji Vakuf. All the production (8,000 to 10,000 annually) was transported to "Elektrobosna" in Jajce.

Besides production, ferrosilicon quartzite is also used in metallurgy for the production of Dinas bricks with 95% of  $\text{SiO}_2$ , and a maximum content of  $\text{Al}_2\text{O}_3$  of up to 2%, and in the chemical industry it is used for the production of materials resistant to acids.

### **Magnesite**

The chemical composition of magnesite is carbonate magnesium with 47.92%,  $\text{MgO}$ , and 52.08% of  $\text{CO}_2$ , with additions of Fe, Mn, Ni, and Ca. It is mostly found in the form of grains, pieces, crystals, and shelly fractions, of a white, yellowish, and brown color. It is created by the metamorphosis of olivine rocks and serpentines or the metensomatosis of limestone and dolomite.

Geological research at Konjuh Mountain discovered a mining zone, of parallel oriented lodes, 6 kilometers long. It extends from Miljevica, over the ridge of Konjuh and Zeničica in the direction of Maoča.

Research and exploitation was conducted by Rudnici nemetala - Kladanj. The raw materials were transported to "Vatrostalna" in Zenica.

The use of magnesite is most important in the refractory industry, followed by the production of magnesium cement, and the production of magnesium metals.

### **Brick clay**

These are less quality raw materials compared to ceramic and refractory clays. They are easily meltable, so that their ignition temperature is from 900 to 1000°C. With regards to



the content of aluminum, brick clay is mostly – acid ( $\text{Al}_2\text{O}_3$  below 15%) or semiacid ( $\text{Al}_2\text{O}_3$  from 15 to 30%).

The use of brick clay is greatly influenced by the demand of the producers of brick products: brick elements, tiles, and others. The main condition is for them not to contain limestone, gypsum, pyrite, gravel, and sand.

Previous research and exploitation included 14 sites, while today, exploitation has been restored only in a few sites in the Federation of BiH: Sočkovac (Gračanica), Golo Brdo (IGM - Visoko), Čavka (Busovača), and Rosulje - Jelah (Tešanj).

### **Pyrophyllite**

There are two known sites of pyrophyllite in the Federation of BiH: Parsovići near Konjic, and Odska near Goražde. In Parsovići, exploitation was conducted, while at Goražde there were not even geological researches.

They are created under conditions of regional metamorphosis or by the effects of hydro-thermal solutions on certain types of rocks, so we differentiate between two types: metamorphogenic and hydro-thermal sites.

Pyrophyllites have a stellate habit; they have a pearly glow, and a greasy feel. They are used in the production of ceramics, paper, paints, and lacquer, as well as in cosmetics and electrotechnics.

### **Pozzolana**

Pozzolana is volcanic tuff, deposited in sea or lake environments from the deposited pyroclastic material. The rocks formed in that way have pozzolanic qualities, and are therefore used in the production of portland cement. Being good filters they are used for the filtering of industrial and food liquids.

The sites of these materials at the Livno basin (Ploče), the carbon basin at Kamengrad, and in Piplić between Gračanica and Doboј, are famous.

### **Technical and construction stone**

This encompasses several rocks: limestone, dolomite, diabase, spilite, quartzolites, serpentine, and amphibolite. Limestone and dolomite belong to sedimentary rocks, while the other rocks are of magma origin. Magma rocks are also called “eruptives”. They are used for ballasts on railway tracks or for surface layers in the construction of roads.

Several sites in the Federation of BiH are exploited: spilites near Vareš (sp. on Table 1.), diabases in Ribnica near Banovići, quartzolites in Radava near Fojnica.

Limestone is exploited at 33 sites, and dolomites are exploited at 39 sites across the Federation of BiH.

### **Architectural and construction (decorative stone)**

Beautiful and decorative types of limestone, of different age, structure of monoliths, and other characteristics were used in BiH in several areas. Just as the situation became favorable for the positioning on the market, and to become recognizable, subsidence occurred, almost shutting down all of the steaming enthusiasm from the starting phase of the research and the selection of the best types. Extraction and processing of the decorative stone began at six sites in the wider area of Posušje, followed by Raška gora and Ortiješ near Mostar, Podmilačje near Jajce (Plivit), Maškare near Bihać, and Sadilova čaira near Šekovići, amphibolite at Vareš, gabbro near Višegrad, Jablanica, and other sites. The same specific situation occurs also with other mineral resources: somewhere excavation begins, soon the enthusiasm starts building up everywhere, but subsidence soon follows.

This is the situation today in the Federation of BiH. What has remained is the exploitation of gabbro near Jablanica, and that is it. Resources and the processing and production industry end there.

## **7.2 Final Considerations**

The analysis of the development of the industry of non-metallic and construction materials in BiH, we come to a very clear conclusion which points to the fact that the identification of the nature of non-metals rose suddenly, which contributed to an increase of scientific approach in their calculations and researches. Bosnia was especially held back by several factors. It was simply "indebted" considering the past development policy of the joint Yugoslavia, for the creation of conditions and the building of heavy industry. In order for it to complete the task, it had to create the conditions for its own expansion. The question is how and in what way? There was no expert staff, no adequate equipment, not enough knowledge, or experience for it to lean on.

During that period, the only things that were known were a few non-metallic mineral raw materials: magnesites, ceramic and refractory clays.

The intensifying of geological research ensured the raw material basis and the raw materials for the needs of the "Vatrostalna", as well as the ferrous metallurgy. A lot of expert staff was gathered, and advancement could be made at the identification of new non-metallic mineral raw materials and the installation of industrial capacities. The production of cement in Kakanj and, partially, the chemical industry in Lukavac, was ensured in such a way.

We have identified around 20 non-metallic mineral raw materials which could ensure industrial capacities for the glass, ceramics, and paper industry, and expand to the construction industry and other branches. A large number of identified non-metallic mineral raw materials located throughout the Federation of BiH can serve as additional industrial raw materials.