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Short study: Mining and Chemical Industry in Bosnia and Herzegovina

Prof. Dr. Udo Boin, Dr. Andreas Schwarz

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Content

1. Mining

Extraction of raw materials by mining can be divided into (a) metals, (b) non-metals and (c) fuels. The metallic raw materials are sub-divided into ferrous and non-ferrous ores (examples of the latter include lead–zinc ores and bauxite deposits in Bosnia and Herzegovina). The non-metallic deposits include clays, magnesite, silica sand, decorative stone and, most importantly, rock salt. The most common fuel is the lignite ("brown coal") typical of Bosnia and Herzegovina, which has a very low calorific value.

1.1 Raw materials and production

The reserves of the various **deposits of raw materials** were last calculated in the mid- to late 1980s.[1] The mines have only been producing very modest tonnages since then, so the old figures can generally still be used.

In 1990 and 1998, the mining industry was **producing** the following tonnages:

	1990	**1998**
• Lignite:	17,937,000 t	7,342,000 t
• Lead/zinc concentrates:	40,000 t	1,500 t
• Bauxite:	1,713,000 t	70,000 t
• Clays:	65,000 t	35,000 t
• Silica sand:	176,000 t	40,000 t
• China clay:	42,000 t	18,000 t
• Dolomite:	250,000 t	43,000 t
• Other minerals:	219,000 t	25,000 t
• Rock salt	303,000 t	62,000 t

These figures show that before the war considerable volumes were being mined: almost 18 million t of lignite, of which roughly 79 % was used for generating electricity, 1.75 million t of non-ferrous metal ores and concentrates, and a total of 1.06 million t of non-metallic raw materials. This amounts to approx. 20.8 million t/year of mining products, which has sunk to approx. 7.6 million t/year within 8 years as a result of the upheavals and other consequences of the war – just over one third of the previous level.

Bauxite

Bosnia and Herzegovina has very extensive bauxite deposits: they amount to more than 30 million t of accessible reserves and are thus amongst the largest bauxite deposits in Europe, along with the deposits in Montenegro. However, the extraction of this bauxite has two disadvantages:

- Relatively low Al_2O_3 content and relatively high SiO_2 content
- High ratio of overburden (waste) to useful ore, which means that the average extraction costs are over US$ 40/t bauxite (in Australia they are around US$ 7–10/t).

[1] For the Republic of Srpska, iron ore reserves of 442 million t have been estimated at Ljubija, near Prijedor, although no more information is available.

Bosnia and Herzegovina's occurrences of bauxite are therefore of relatively poor quality and comparatively expensive.

The fall in aluminium oxide production has been especially dramatic for Bosnia and Herzegovina. As the site in Zvornik produced almost 550,000 t of aluminium oxide a year before the war, about 1.5 million t of raw bauxite had to be delivered. Today the plant at Zvornik is so run down that only around 200,000 t of aluminium oxide can be produced a year, requiring roughly 550 000 t/year of bauxite. However, since the bauxite from Srebrenica/Milici/Vlasenica is of relatively poor quality and high overburden levels make it very expensive, Zvornik obtains a large proportion of its bauxite from Jaice, which is a long way away, and Niksic in Montenegro, which is even further away. Bringing the bauxite the 450 km from Niksic by lorry makes its effective price just as high, but it is of markedly better quality. This explains the disastrous decline in bauxite production in the mines of Bosnia and Herzegovina, reflected in an annual loss of turnover of around US$ 290 million.

Bauxite used to be of considerable domestic value, as all of the larger Yugoslavian states still had their own aluminium oxide factories and aluminium smelting works. Now the only aluminium oxide plant in Bosnia and Herzegovina is the one in Zvornik, and Mostar has the only aluminium smelting works (there is also Podgorica in Montenegro). However, the smelting works in Mostar is supplied with aluminium oxide from Sardinia, which is of better quality than the aluminium oxide from Zvornik and can be reliably supplied in large quantities.

Lignite

Bosnia and Herzegovina has very extensive deposits of lignite.[2] The following details are available on coal mining regions in Bosnia and Herzegovina:

- Kolubara region: capacity 31 million t/year; 13-18 % ash; 0.4 % S; 7-9 MJ/kg
- Ugljevic region: capacity 1.6 million t/year; 25 % ash; 5 % S; 10-11 MJ/kg
- Tuzla region: capacity 8-11 million t/year; 7-12 % ash; 8.5-9 MJ/kg
- Sarajevo region: capacity 0.5 million t/year; 12-16 % ash; 4.5-5 % S; 21 MJ/kg.

Local surveys provided further information about reserves of lignite and black coal in the Republic of Srpska:

- Ugljevik area: black coal — Reserves: 258 million t
- Zap Kozara area: black coal — Reserves: 600 million t
- Miljevina area: black coal — Reserves: 43 million t
- Starani area: lignite — Reserves: 144 million t
- Gacko area: lignite — Reserves: 266 million t
- Ramici area: lignite — Reserves: 37 million t

The most recent estimates assume that there are lignite reserves of approx. 2.1 billion t in Bosnia and Herzegovina. The calorific value of these coals is between 7 and 21 GJ/t coal, which is comparable with German peat. This means that these coal deposits are of relatively poor quality with a high moisture content and that transporting them more than 50 km is not economically viable. Thus almost 80 % of them is used for generating electricity and combined heat and power in power stations close to the pits. Exporting these coals is out of the question. The figures given above show that these coals have the disadvantages of large amounts of combustion residue and high SO_2 emissions. Due to the low level of automation,

[2] Unfortunately, the available information is not sufficient for an assessment of the environmental impacts of burning these coals; inter alia, the sulphur content of these lignites could not be determined.

the underground pits have coal losses of around 20 – 50 %, while the open-cast mines have coal losses of 10 – 15 %.
The following information was obtained concerning the so-called “black coals”:

H_u	11,200 kJ/kg
% S	3.3
% C_{fix}	17.61
% ash	18.69
% moisture	33.0.

These figures show that the so-called black coals are also of relatively poor quality, which means that optimisation of combustion and the costs of drying and extraction override other considerations. In addition, there are very recent extensive studies written in the local language about the generation of electricity from coal in Bosnia and Herzegovina, inter alia that of Rheinbraun, which mentions a limiting value of DM 4/GJ, which would correspond to maximum costs of DM 45/t for 11.2 MJ/kg, and limiting costs of DM 84/t for a coal of 21 MJ/kg. One has to conclude that for most of the coal mines in Bosnia and Herzegovina, such low costs can only be achieved with very high extraction rates, i.e. more than could be used for generating electricity. This means that only the mines with the highest calorific values are of any interest.

Ores containing lead/zinc

The total global deposits of ores containing lead/zinc are relatively modest, but here the mines are either closed or else have apparently been unsatisfactorily maintained.

The accessible (usable) reserves of lead/zinc ores in the area of Srebrenica/Olovo/Vares were originally put at 7.5 million t. Before the war, the mine was producing around 350,000 t/year, with approx. 2.4 % lead and 3.18 % zinc, i.e. about 8,400 t/year of lead and 11,100 t/year of zinc.
At the mine, the extracted ore produced concentrates containing 6,500 t/year of lead and 7,500 t/year of zinc, i.e. lead extraction was running at 77 % and zinc extraction at 68 %. Both these figures are low in international terms, i.e. too much metal is already being lost during treatment of the ore. The lead and zinc not recovered must therefore be present in the waste, which suggests considerable environmental damage and contamination. A lead/zinc mine in Montenegro is known to have left behind a mountain pool with high levels of heavy metals. No new operator wants to re-open the mine, because to do so would mean having to deal with both the old and (probably) also new environmental problems. It is to be feared that the treatment plant at the mine at Srebrenica has also created a similar mountain pool, and re-opening would therefore initially require the rehabilitation of the old pool and investment in a new, secure mountain pool – which would incur even higher costs for the relatively small mine.

Silica sand, limestone and clay[3]

Silica sand (Tuzla region, Prijedor) is a valuable mineral which can be used in the glass industry (e.g. at Zvornik) and for building up a range of aluminium oxide-silicate products. Silica sand is present in notable quantities, but to date has not been accessed on a suitable scale, let alone extracted.

The limestone in the region of Lukavac and Srebrenik is an important raw material for the local construction industry and for the “still” extant soda factory at Lukavac; importing it would be very costly. However, its extraction is more “quarrying” than “mining”.

[3] There are said to be deposits of gypsum near Novi Grad (formerly Bosanska Novi), but detailed information was not available.

The numerous deposits of ceramic clays could be a vital basic material for a ceramics and glass industry if they were accessed and there were sufficient technology available for extraction.

Rock salt

The rock salt deposits in Tuzla are presumably the most important non-metallic raw materials in Bosnia and Herzegovina. They were opened up under the imperial monarchy in the last century, and the regime in power before the war ordered the construction of a chlorine plant around the salt production. After the war most parts of this combine rapidly proved to be non-viable when confronted with the open global markets. However, it is only what the previous regime did with the salt in the planned economy that is now largely unprofitable. The salt itself, which is present in large quantities in the Tuzla region, is of high quality and the deposits are unique in former Yugoslavia. Bosnia and Herzegovina thus potentially has a large volume of raw materials which, if modern marketing and research methods were used, could become the basis for attractive products for neighbouring markets.
The old mine was recently replaced by the new salt mine Tetima, 12 km from the town of Tuzla. The reason for this was that the old salt mine, which lies beneath the town, had caused dramatic subsidence as a consequence of the dissolving procedure used in the previous decades. For example, an area of several hectares in what used to be the town centre subsided by up to 12 m, leading to the demolition of 2,700 dwellings and the relocation of 15,000 residents. The new salt mine has geological reserves of approx. 375 million t rock salt, which would last for generations, even at the high rate of extraction of 1 million t salt per year.

Magnesite

The magnesite near Kladanj is claimed to have delivered 36,000 t of raw magnesite (although the time frame is not known) to Zenica before the war. Since the war it has not been operating. The reserves are put at 1.7 million t (with a 20 % magnesite content). If these figures are correct, the deposit is small and obviously difficult to work. Unfortunately, the old pre-war plans to produce magnesium metal from this ore are completely unrealistic: the deposit is too small, magnesium production requires at least 18,000 kWh/t, i.e. more energy than any other metal (which is why electrolytic magnesium production is only viable in Canada and Norway), and the cheap silicon required for the Pechiney procedure is not available in Bosnia and Herzegovina. Here, too, a demand for MgO must be found before the removal, treatment and calcination of the raw magnesite is considered.

1.2 Development prospects

Most mining operations run in cycles. That is, they vary along with macro-economic activities in the country, whilst also being affected by price fluctuations on the global raw material markets. These mechanisms not only make it impossible even for professional forecasting institutes to reliably predict changes in metal prices, but also prevent forecasts about the future of the mining industry, either for individual metals or for the raw materials of an individual country. In addition, any existing trends are also eclipsed by global economic developments and the various regional recycling activities. For example, the European demand for natural raw materials is characterised by high quality, low prices and consumption which will continue to stagnate in the long term. In addition, recycling is increasing in Europe, which means that natural raw materials only need to be used to cover the unavoidable losses in the cycle and to maintain product quality.

Large ore mines and their treatment plants generally have long-term supply contracts with suitable smelting works – contracts which include “incentive-penalty” stipulations to cope with possible pollution which would make smelting more difficult. However, Bosnia and Herzegovina’s mining operations cannot be assessed on the basis of these contracts, because some of them stopped delivering regularly several years ago – if indeed they ever had long-term supply agreements with smelting works, presumably in former Yugoslavia.

Bauxite

Before the war, the bauxite mines supplied the aluminium oxide factories in Slovenia, Croatia, Bosnia and Herzegovina, and Serbia/Montenegro. These customers have disappeared, with the exception of Zvornik, which – as mentioned above – has produced well under capacity since the war ended. Due to the relatively poor quality of the bauxite in Bosnia and Herzegovina and the relatively high costs incurred by the high ratio of overburden to ore, the chances of this raw material breaking onto large markets are rather bleak.

The future of Zvornik, the only purchaser of bauxite from Bosnia and Herzegovina, is also extremely uncertain. Maintaining the present low level of operation over the long term is sure to lead to bankruptcy. There is currently an interested investor, although the authorities have not yet given him the opportunity to make the urgently needed investments.

For the reasons already described, exporting bauxite is illusory, with costs of over DM 50/t bauxite FOB for the mines in the Srebrenica/Vlasenica area. If any of the mines has a theoretical chance, it is the one in the Jaice area, with its lower costs, which could supply aluminium oxide plants in Italy via the port of Ploce. However, it must be stated clearly that the quality of the bauxite from Bosnia and Herzegovina cannot compete with that imported from Africa, Jamaica or Australia.

The bauxite pits will only justify investment, preferably in exploration and transport systems, if Zvornik can bring production of aluminium oxide back up to its original level of 600,000 t/year. However, following an extensive investment programme, Zvornik would only be in a position to transport the aluminium oxide produced by shipping it eastwards on the River Danube, and not by lorry or railway (which itself could not manage this at present anyway) westwards to the Adriatic coast.

Furthermore, the European aluminium industry is developing in a way that will disadvantage Bosnia and Herzegovina. Owing to the high costs of electricity and personnel, primary aluminium production is leaving Europe, while secondary aluminium production will continue to grow rapidly. Thus, even if Bosnia and Herzegovina could produce aluminium oxide from its own bauxite at a reasonable cost, there would no longer be any European customers for it in the long term. If anything, Zvornik would have to concentrate on the production of specialised aluminium oxide and find markets for it in south-eastern Europe.

Lignite

As mentioned above, the lignites in Bosnia and Herzegovina have low calorific values and considerable moisture content. In addition, in some regions coal mining is still suffering from a high ratio of overburden to coal of up to 7 to 1, which means that up to 7 tonnes of overburden (waste) have to be removed for each tonne of coal. The resulting costs make the poor-quality coal even less economically viable. This means that only those coal mines with the highest calorific values, lowest moisture content and the shortest distances to local power stations will be able to survive; the rest will inevitably soon have to close down. Because of the high sulphur content, the power stations urgently require appropriate gas purification systems.

The quality of the lignite does not allow conversion into coke, so consumers of coke in Bosnia and Herzegovina have to use imported material despite the country's large coal reserves. Sufficient data is not available to look at the possible production of lignite briquettes from a technical point of view; in any case, such use of lignite cannot be recommended for environmental reasons.

In view of the low calorific value of the lignite in Bosnia and Herzegovina, there is no point in investing in increasing extraction. This lignite can only be used in thermal power stations close to the mines. It would be of more benefit to the coal mining industry to invest in gas purification at the power stations, in optimising the combustion technology and in the railway lines between the mines and the power stations than to invest in expanding the mines themselves. If there is to be any direct investment, it should be solely directed towards safety measures in the mines.

Lead/zinc ores

The lead/zinc ores in the Srebrenica area have an accessible content of 180,000 t lead and 235,000 t zinc, which is definitely too low to support a lead/zinc smelting works in the area. A smelting works was originally planned, but it would only reach a production capacity of just about 15,000 t lead and zinc per year, figures so small as to make cost-effectiveness a forlorn hope. Thus the only option for old lead/zinc mine and its treatment plant might be as a co-supplier to the lead and zinc smelting industry in Serbia.

Lead and zinc concentrates could be supplied to Trepca near Mitrovica, Serbia, which can be recommended due to the relatively high silver content. It would only be possible to assess exporting the concentrate beyond former Yugoslavia if information about the lead/zinc content of the various concentrates were available.
The only profitable investments in this are of mining would be in safety and environmental protection measures and in additional exploration activities, provided that the lead/zinc concentrates turn out to be suitably rich.

Silica sand, limestone and clay

Due to the lack of information on the quality of the reserves of silica sand (inter alia, Fe and Cr content), it is impossible to determine whether they would be suitable for use in glass works. However, high-quality silica sand is a valuable and desirable raw material for the glass/ceramics and silicate sector. The authors of this analysis proposed to Zvornik that the manufacture of aluminium silicate products, i.e. products such as rock wool, detergents and molecular sieves/zeolite, which was begun before the war, should be further expanded on the basis of aluminium oxide and sand. With these expensive products on the market in former Yugoslavia, Zvornik could exploit its raw materials and its technological know-how, which is now unique in Bosnia and Herzegovina. Zvornik had responded with the consequent desire to exploit a nearby silica sand deposit. To date it has not been possible to realise these projects owing to insufficient funding. If analysis of the sand reveals satisfactory quality, a market survey in Bosnia and Herzegovina is urgently required.
Aluminium silicate production in Zvornik should definitely be followed up, regardless of whether the aluminium oxide factory is closed or not; sufficient stocks of aluminium oxide should be produced for this eventuality.

In view of the continuing requirements of the building industry, the open-cast mines producing limestone will most probably be able to continue operating economically, since the extraction of the cheap limestone is only dependent on the local demand, which is fairly high at present.

Rock salt

The salt deposits at Tuzla are probably the country's most important natural resource. The opportunities for utilising this good-quality rock salt lie in a systematic product and marketing analysis for the salt products which can be manufactured directly from it, such as table salt, cooking salt, seasoning salt, salts used in manufacturing and industry, and medical/pharmaceutical salt products (e.g. physiological saline solution or Ringer's solution).
A human being's required daily intake of salt is about 5 g/day. This means that Germany requires approx. 450,000 t cooking salt annually, only one third of which is covered by packaged cooking salt, while two thirds go to meat processors, bakeries and manufacturers of preserves. The corresponding requirement of table salt for Bosnia and Herzegovina's 3.6 million inhabitants is around 18,000 t/year. As there are no other salt deposits in former Yugoslavia, Tuzla has in theory a potential salt market of up to 25 million people, although since the war broke out the Austrian salt works have been the principal suppliers.[4] It is telling that it is precisely these Austrian salt works that are very interested in the salt deposit at Tuzla.

In future, the petroleum industry will be interested in the washed-out salt cavities, as it could use these empty cavities as reservoirs for natural gas, particularly if the planned natural gas loop-pipeline in south-eastern Europe is realised. Because of the density, only salt deposits can be considered, so Tuzla is the only place in former Yugoslavia where old cavities can be used in this way. Such utilisation would not only bring financial income, it would also protect against further subsidence.

Exploitation of the salt deposits in Tuzla is ensured by the new mine constructed at Tetima. The previous idea of operating a complete chlorine plant based on the chlorine content of NaCl is unrealistic owing to the outdated technology, the huge amount of environmental damage, the logistically difficult location and the fact that southern Europe now already has over-capacity.
Instead, value added must be created with desirable salt products. For example, the value of common salt in the physiological saline solutions is calculated at DM 300,000 /t NaCl. Such considerations suggest continuing operation of the chlorate plant in Tuzla. In this plant, electrical energy is used to produce $NaClO_3$ from common salt. The product is a bleach, much sought-after in industries such as paper manufacturing. The constant output of the last 10 years indicates that production is reliable.

Soda extraction at Lukavac could only be justified if an investor would invest in modern technology for obtaining heavy soda and if simultaneously the existing plant were demolished and the existing contamination were cleaned up in an environmentally sound manner. Otherwise, it would make more sense for Bosnia and Herzegovina to cover its soda requirements with imports. If the soda factory were to be closed, the local limestone

[4] For example, Fresenius is supplying large areas of the Balkans with infusion solutions from Austria, which are effectively being transported past the salt at Tuzla.

extraction at Lake Modarac would lose its most important customer and would urgently need to find new ones in the building industry.

2. The Chemical Industry

The chemical industry is built upon two basic classes of raw materials: inorganic raw materials such as common salt, phosphate and lime, and organic raw materials such as coals and oil. The chemical industry in Bosnia and Herzegovina can thus be divided into two corresponding categories:

a) primary chemical industry and
b) organic chemical industry.

The inorganic raw materials are generally used for manufacturing additional basic chemicals: phosphates are used for making phosphoric acid, fertilisers etc., and lime is used in the manufacture of calcium cyanamide, which in turn serves as the basis for further branches of the chemical industry. The whole chlorine industry is based on common salt, producing not only soda and sodium hydroxide but also hydrochloric acid and PVC. This means that the inorganic chemical industry is essentially broken up into ever deeper niches for producing value added. It is built upon certain compounds of low molecular weight made up of numerous elements such as metals (Na, K, Ca, Mg, Al) and non-metals (O, N, C, Cl, F, S, P, Si, B, H, I, Br). The primary chemical industry is generally developing in the direction of product depth.

By contrast, the organic chemical industry is largely diversifying its range of products, i.e. compounds of high molecular weight are ultimately being synthesised from only three elements (C, H and O).

2.1 Raw materials and production

Bosnia and Herzegovina's chemical products fall into the following groups:
Products derived from salt, which were previously manufactured for the protected and closed Yugoslavian market. Customers' wishes and the transportation distances were of no importance. In addition, products such as TDI and polyols were manufactured using imported basic petrochemicals.
Products derived from coke, which were also intended for the protected Yugoslavian market.
The production figures in the chemical industry in Bosnia and Herzegovina over the last 20 years reveal the following products, most of which can be assigned to the two major chemical categories mentioned above:

- Salt-based/at Tuzla [t/year]

	1980	**1990**

Hydrochloric acid	8,100	59,000
Caustic soda	71,700	72,000
Soda	129,000	173,000
Chlorine	28,200	47,600
Sodium hypochlorite	31,400	43,000
Sodium chlorate	3,800	4,000
Polyol	18,700	24,800
TDI	---------	15,000
Washing detergents	42,800	47,300

- Coke-based/at Lukavac [t/year]

	1980	**1990**
Nitrogenous fertilisers	96,000	70,000
Ammonium sulphate	11,100	13,200
Maleic anhydride	5,900	9,500

In addition, Bosnia and Herzegovina also manufactures ammonium nitrate and nitric acid (Gorazde), polyester fibres (Banja Luka), phthalic anhydride (Teslic), and PVC (Jaice), polyethylene, polystyrene and epoxy resins, all produced without exception from imported raw materials or precursors. Even before the war, the volumes produced were modest, at only a few thousand t/year (exceptions being ammonium nitrate and nitric acid, at approx. 20,000 and 100,000 t/year, respectively).
It should be mentioned that the production of detergents also relies completely on imported precursors.

The statistics for the year 1989 indicate 21,170 people employed in the chemical industry in Bosnia and Herzegovina.

The chemical industry has been seriously affected by the war, since it was largely dependent on the protected Yugoslavian market. The infrastructure, transport systems, electricity supply and the suppliers of primary chemicals in Serbia suffered massive damage (including Pancevo). Furthermore, a considerable number of well-educated chemists and process engineers have now emigrated. In 1990, the country made 900,000 t of chemical products, but by 1998 this had shrunk to 95,000 t, i.e. only slightly more than one tenth.

2.2 Development prospects

For the primary chemical industry, it is essential that the various raw materials should be available in suitable quality and quantity at a good price.
For example, the phosphor industry is concentrated directly around phosphate deposits (such as Florida and Louisiana in the USA) or in ports allowing operators to land phosphates that can be transported cheaply (Bremerhaven).
Similarly, chlorine plants are built close to occurrences of rock salt, e.g. at Tuzla.

Organic chemical plants do not have to be close to coal mines or oil wells, since both of these fuels are shipped all around the world. The large petrochemical plants are therefore usually located at ports (either on rivers or on the coast).

In addition, such issues concerning the location are nowadays eclipsed by the need to be close to the market for cost reasons. This is another aspect that makes it virtually essential for today's chemical industry to be on the coast.

These observations indicate the following tendencies in Bosnia and Herzegovina's chemical industry:

a) The **primary chemical industry** in Bosnia and Herzegovina must limit itself to salt as a raw material, since there are no other large deposits of raw materials; however, the salt lies far inland, and the transport infrastructure necessary for reaching the ports at a reasonable cost is in very bad condition; when the products are exported, they therefore have the disadvantage of being expensive. Moreover, the products from Bosnia and Herzegovina have to face global competition, since large, new facilities in neighbouring countries have long since started to supply the countries of former Yugoslavia. These plants have the advantages of greater throughput, modern technology and proximity to oil ports (along the Danube). There would be no economic sense, for example, in setting up small-scale production of polyurethane in Tuzla, the manufacture of which would only require a modest amount of chlorine as an oxidant, to compete on the Serbian market against foreign competition. These competitors have their own petrochemical refineries at the Danube ports and can also ship their bulk chemicals via the Danube.

   The need to be close to one's own raw material deposits and river or sea ports, and to be close to potential customers, means that the only economically viable prospect for the primary chemical industry in Bosnia and Herzegovina is the systematic development of salt or similar products.

   To this end, the chemical research institute at the University of Tuzla should channel its expertise in salt chemistry into further developments. However, the deciding factor should not be what the salt plant can produce, but solely the requirements of the customer. As described in detail in the study on the mining industry, in the countries of former Yugoslavia there is a great demand for cooking salt, infusion solutions and salt for preserving hides, which without salt from Tuzla can only be covered by imports.

   Further diversification into a sodium and a chlorine industry at Tuzla makes no sense. Quite apart from the fact that any acceptance of this type of industry has been completely lost there, there is no cheap electricity to justify continuation of the environmentally harmful chlorine and sodium hydroxide production. Furthermore, the customers are located on the Danube, which is a long way away from Tuzla. It would make more sense for Bosnia and Herzegovina to sell its high-quality industrial salt to the nearest operators of chlorine-alkali electrolysis.

b) The **organic chemical industry** cannot use the low-quality lignites found in Bosnia and Herzegovina as raw material. Previous attempts at building up this type of industry in the area around Tuzla were based on the salt-dependent chlorine industry, and various primary petrochemicals were imported from Serbia. In the Lukavac area, an organic chemistry complex was begun based on imported hard coal, which was carbonised. However, an organic chemical industry in the middle of a land-locked country, far from shipping routes (e.g. SODASO/Tuzla) and based on imported precursors, cannot be viable in the long term.