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Saxon Raw Material Strategy

The raw material economy –

An opportunity for the Free State of Saxony

Contents

1. Foreword

Martin Dulig
Saxon State Minister for
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Labour and Transport

Dear readers,

"Everything comes from the mine." This old German saying not only attests to the pride of our miners; in its simplicity, it also describes something many people no longer even realise: that raw materials are an indispensable basis for everything around us that we take for granted every day.

Many people consider mining to be too dirty and outdated. An ever-developing economy, though – be it industry, agriculture or trade –, a future-oriented infrastructure, a changing mobility concept, modern information and communication technology, or even a modern health system could not exist without mineral resources.

Germany's reliable supply of raw materials – in terms of quantity and quality, as well as its ever-changing diversity – is a key pre-requisite for our added value. The availability of those resources will thus continue to be an important factor for growth and our society's wealth in the future.

Given Germany's dependency on importing a number of raw materials, particularly metals, our economy needs to come to terms with the global raw material situation, primarily characterised by the widespread geographic distribution of deposits, growing worldwide demand, and a dramatically evolving range of raw materials.

Coupled with this are political challenges associated with countries producing these resources, rising social challenges, and greater requirements placed on the environment by mining. The complexity of all those factors makes it impossible for them to be totally controlled. The German economy's resulting dependencies, which are far from clear-cut, can, for example, be influenced by clever actions in international raw material policy. Another option for reducing dependencies – increasing usage of our local raw materials and the expertise of the local raw material economy, both in mining and recycling – is one within our own control.

Saxony has considerable potential when it comes to local primary raw materials used in a wide variety of sectors, and the secondary raw materials obtained from waste are also becoming an increasingly important, if not even indispensable source. Primary and secondary materials from local sources thus not only help minimise dependencies on international raw material markets using them also plays a key part in regional value creation and securing jobs.

One source of regional value creation which cannot be overstated is the traditionally strong degree of networking between numerous stakeholders in both the Saxon and international raw material economy. Here in the Free State, stakeholders associated with raw material research and education, as well as our mining administration, make a significant contribution towards ensuring Saxon raw material economy is focused on the future.

The "Saxon Raw Material Strategy" passed by the Cabinet in 2012 aims to integrate this potential into an overarching economic scheme for a sustainable raw material economy. It is intended to serve as a guide for the Free State's raw material policy, with a conscious focus on primary

mining-related raw materials – such as pit & quarry natural resources, coal, ore and spar – and secondary materials reclaimed from waste, which can substitute mined raw materials.
The issue of renewable raw materials has purposely not been incorporated into this strategy, just as the challenges associated with designing production processes in terms of material efficiency, such as saving raw materials in production processes and product design, have similarly been left undiscussed. This is the subject of other strategic considerations and publications.
The present raw material strategy establishes the guidelines, objectives and tasks of the Saxon raw material policy, whose main aim is to help devise framework conditions to revive local mining and further develop the secondary resource industry in Saxony.
Another of our aims is to continue promoting the Free State as a raw material hub, and improving opportunities for the Saxon raw material economy.
The raw material strategy remains in effect and up-to-date. Initial tasks have been tackled, and the first results are already visible. One noteworthy example here is the ROHSA, a key project run as part of the strategy, and which has achieved great success in digitising the existing geological data for spar and ore and making this accessible to the economy. This has attracted worldwide attention, and has resulted in around 50 mining permits (exploration and mining approvals) so far being issued. It gives us confidence that ore and spar mining recommence in the Ore Mountains in the future.
Implementing the raw material strategy is the responsibility of the entire community. It is further a particular priority of mine to ensure people are made more aware of the importance of raw materials in developing our society. A growing, knowledge-based awareness of these raw materials is just as valuable to our community as clear, economically-based environmental awareness and social awareness based on human values.
To modify the mining saying I mentioned at the start: “Everything comes from raw materials.” This has always been the case, and will continue to be so in the future.

Because securing raw materials means securing the future.

As the German miners used to say, Glück auf!

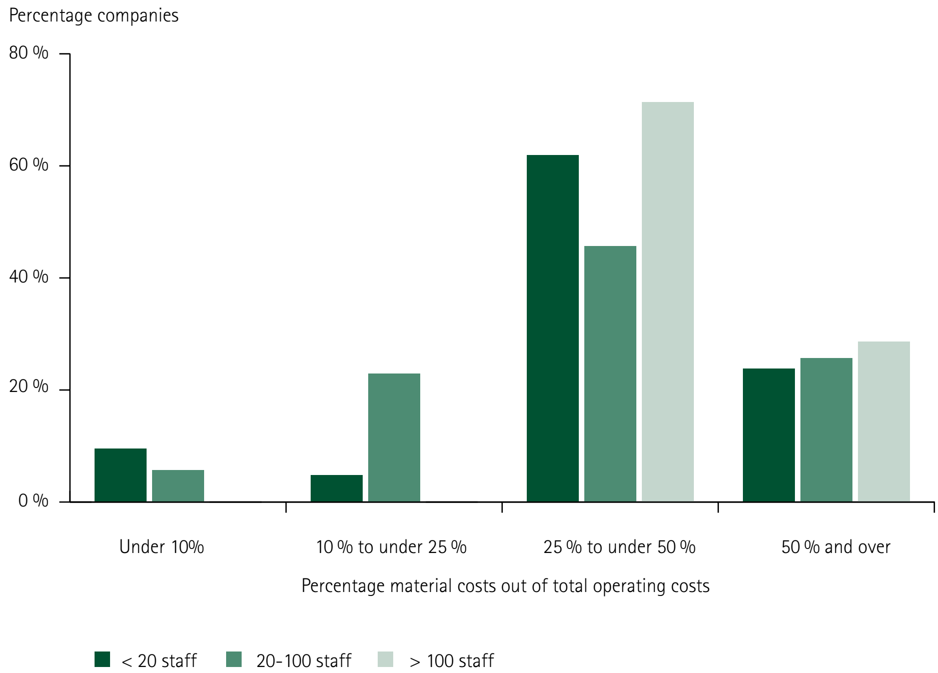
Martin Dulig
Saxon State Minister for Economic Affairs, Labour and Transport

2. Raw materials critical for industry

Analyses of company surveys conducted by the Institute for Futures Studies and Technology Assessment (IZT) found that rising commodity prices pose a problem for 76 percent of companies, particularly industrial companies (93 percent), as material costs make up more than 20 percent of the total costs, and therefore play a key role in net operating results. There are also increasing doubts about whether raw materials will be in adequate supply (47 percent). In the coming years, access to and availability of said raw materials will be critical factors in determining which regions become home to new industries.

A study by the South-West Saxony Chamber of Industry and Commerce revealed the same results:

Figure 1
Share of material costs in Saxony's total operating costs



Source: South-West Saxony Chamber of Industry and Commerce, 2007

The increased demand among future technologies proportionate to today's worldwide production will see a dramatic change in the global demand for raw materials.
The IZT study entitled "Raw materials for future technologies" examined how much of the respective worldwide raw material production in 2006 was made up of selected future technologies, and how much of today's worldwide production of the respective raw materials is expected to be needed for these technologies in 2030:

Raw materials	2006	2030	Future technologies (selection)
Gallium	0.28	6.09	Thin-film solar cells, IC, WLED
Neodymium	0.55	3.82	Permanent magnets, laser technology
Indium	0.40	3.29	Displays, thin-film solar cells
Germanium	0.31	2.44	Fibre-optic cables, IR optic technologies
Scandium	low	2.28	SOFC fuel cells, Al alloying element
Platinum	low	1.56	Fuel cells, catalysis
Tantalum	0.39	1.01	Micro-capacitors, medical technology
Silver	0.28	0.78	RFID, lead-free solders

These selected raw materials from the study show that it is necessary to increase both their production and their reclamation in order to meet the greater demand of the future. The world's growing population and the desire for equal living conditions will also cause commodity markets to evolve and demand to keep rising.
The "Raw materials critical for Germany" study conducted on behalf of the KfW bank classified the supply situation for 13 raw materials as particularly critical, since shortages in these materials have a more serious impact on the German economy compared to other raw materials. In addition to concentrating mining here on a handful of producing nations like China (antimony, fluorite, germanium, graphite, indium, magnesium, rare earths, and tungsten), South Africa (platinum metals), the Democratic Republic of the Congo (cobalt), and Brazil (niobium and tantalum), it found that these could not or could only rarely be used, and that reclaiming them as secondary raw materials is currently very difficult to justify at an economic level.

2.1 Raw materials mining in the economic value chain

Every value chain starts with a raw material. The old German saying of "everything comes from the mine" is today just as relevant as ever: no raw materials means no industrial production, and no industrial products means no service sector. A study conducted by the German Federal Institute for Geosciences and Natural Resources in 2008 found that Germans use between 1,000 t and 1,100 t of raw materials each during their lifetime. Mineral resources, i. e. metals, industrial minerals, pit & quarry natural resources, make up almost two thirds thereof.

Figure 2

Consumption/usage of mineral and energy resources in Germany during an 80-year lifetime

Sand and gravel	245 t	Kaolin	4.0 t
Hard rocks	215 t	Aluminium	3.0 t
Lignite	170 t	Copper	2.0 t
Mineral oil	105 t	Peat	2.0 t
Natural gas (in 1000 m³)	95	Bentonite	0.7 t
Limestone, dolomite	70 t	Zinc	0.7 t
Black coal	65 t	Potash (K_2O)	0.6 t
Steel	40 t	Sulphur	0.5 t
Cement	27 t	Lead	0.4 t
Rock salt	14 t	Feldspar	0.4 t
Clays	12 t	Fluorite	0.4 t
Quartz sand	9 t	Barite	0.3 t
Gypsum, anhydrite	7 t	Phosphates	0.1 t

Non-metallic resources — Metallic resources — Energy resources

Source: BGR, 2008

What most people don't realise is that everything starts with raw materials, as those resources are mined in other parts of the world and are only processed here. There is an expectation that "raw materials are commodities which always seem to be available, need to be cheap, and usually come from far-flung countries."

The constant availability of raw materials on the global market is no longer a given, and may have significant impacts on production in the industries affected. The damage potential for raw material supply shortages and future technologies is classified as very high, because this can disconnect industry from development and render it uncompetitive, particularly in cases of heavy dependence. More and more alternative materials are being used in order to consistently comply with the new requirements, which has resulted in ore (previously deemed irrecoverable/ tipped onto waste dumps) today coming sharply into focus. Whenever there are substitution options to preserve high-quality production, the unavailability of a replaceable raw material is classified as uncritical. Nevertheless, this often falls short in terms of technical feasibility or public acceptance of the substitute materials.

For industry, this means assessing the criticality (availability) of all raw materials used to ensure suitable measures can be taken to combat any actual risk.

2.2 Developing available raw materials

Raw materials are not renewable, and competing usage interests are often opposed to the resources being mined. The fears expressed by the Club of Rome in its 1972 The Limits to Growth study, which claimed that most of the raw material deposits used at the time would be exhausted by the turn of the century, did not eventuate, as new geological findings and modified price structures and resource technologies have led to the discovery of new deposits and enabled known deposits to be rendered profitable. The development of new technologies has also resulted in increasingly efficient handling of available resources. As things stand today, the geological availability of most raw materials does not appear to have a short-term or medium-term limit. Raw material reserves will continue to change depending on the economic and political climate. The availability of strategic raw materials in the foreseeable future has, however, been rated as critical.

Economic growth remains focused on raw materials, as evidenced by China. While China has been an exporter of said resources in previous decades, the tables have now turned. The announcement to drastically reduce the exporting of rare earths as coveted high-tech raw materials is not so much the result of a serious shortage, but rather a plan geared around competition and market dominance.

Using local supplies to artificially favour domestic production and securing the raw materials necessary for this local production by signing exclusive contracts with the producing countries has become a strategic trade policy tool. Export taxes on ore, export licences and export bans will also play a role as possible tax instruments among other providers in future.

It is assumed that the demand for raw materials in so-called "newly industrialised countries" will continue to grow, and this rising demand intensifies competition and pricing on the commodities market.

In addition to the aforementioned focus on a few producing nations is the fact that many of these nations lack legal security, infrastructure and investments. As such, they pose a risk in terms of long-term, reliable supply. Political and social instability in recent years has often seen existing contracts neglected, investments not secured, additional levies charged, and the ownership structures at mining companies altered. Irrespective of this, the financial expense to explore and unlock new deposits will continue to grow, due to the fact that these deposits will be more difficult to access and have lower contents, necessitating added and more cost-intensive technical expense. In many cases, a raw material is only worth mining if the deposit also contains other raw materials. If it becomes unprofitable to mine the main product, even the potentially useful accompanying resource will not be extracted, thereby increasing its shortage on the market. On the other hand, too many unwanted by-products in the deposits can result in unprofitability.

3. Federal and EU strategies

(European and national framework conditions)

Guaranteeing a reliable supply of raw materials is primarily the task of commercial enterprises. The state's task is to create the political, legal and institutional framework conditions for an internationally competitive supply of raw materials. The political challenges affect economic and environmental policy, as well as foreign, trade and development policy.
Some initiatives have already been taken at a European and federal level to ensure Europe and Germany are supplied with raw materials over the long term. The German federal government believes the framework conditions for using local resources should be improved without having to limit environmental regulations. The federal states in particular are being called on to place equal emphasis on securing raw materials as part of their land-use plans.
The establishment of a German mineral resources agency in the form of the Federal Institute for Geosciences and Natural Resources in Hannover in autumn 2010 saw the Federal Ministry for Economic Affairs create a central raw materials service for the German economy.

The tasks of the German Mineral Resource Agency are:

- To establish a raw materials information system in order to increase transparency on the commodity markets
- To directly assist German businesses within Germany and abroad in relation to raw materials issues
- To provide professional support for the federal government's funding programmes
- To examine raw material resource potential within Germany and abroad ahead of economic trends, and establish national partnerships to procure raw materials from abroad.

The European Commission updated the previous EU raw material strategy in February 2011. The EU employs a three-pillar strategy to ensure a reliable supply of raw materials:

- Raw materials diplomacy, assisting with investments in developing nations to mine and transport raw materials, conclude trade agreements, and monitor export restrictions
- Promoting a sustainable supply of raw materials
- Increasing resource efficiency and recycling

The EU Commission's initiative also seeks to improve permit processes in member states' mining industries, and improve resource data in the community by strengthening and networking the State Geological Survey.
The EU Commission's and German federal government's main focuses are on international raw material trade and on reclaiming basic materials from waste.

4. Raw materials in Saxony


Lithium ore | Source: TU BAF

As a region rich in raw materials, Saxony advocates placing an additional focus on ensuring and developing the local supply of raw materials (see maps 1 – 3). This is based on organic, intertwined industrial-economic structures, starting with companies specialising in mining and reclaiming raw materials, and covering all stages of further processing, production, application and reuse.
Mining enjoys a solid public reputation thanks to its centuries-old history and the ever-growing wealth brought to Saxony as a result – as also evidenced by the mining tradition embraced widely across the Ore Mountains. People know the influence mining, industry and trade have on jobs, prosperity and standard of living. The increased environmental awareness and high environmental standards in Germany do not contradict this. The environment and the raw material economy must instead continue to be viewed and addressed in tandem, because efficient handling of raw materials for humans and the environment brings greater benefit for current and future generations.

4.1 Local raw materials

Centuries of intensive exploration and mining means Saxony possesses a comprehensive body of geological and deposit-related information. Using and updating this for known deposits is of significant economic importance to potential mining investors, as is currently the case with ore, spar and lignite.
As early as autumn 2006, the Saxon State Ministry for Economic Affairs, Labour and Transport (SMWA) contracted the Geokompetenzzentrum to reassess Saxony's main ore and spar deposits based on the conditions at hand. The existing data, e. g. regarding supplies, depth and mineralisation, was used to reclassify the supplies in terms of their quantity (small, medium or large based on a global scale) and quality (geological awareness, feasibility, mineability) according to UN supply classification criteria, and estimate the manufacturability of the raw materials. The data was also compared with the raw materials deemed "critical" in multiple recent international studies and with Saxony's known deposits. This comparison showed that Saxony has a substantial supply of these "critical" raw materials. As a result, various national and international companies have increasingly been expressing interest in resuming ore and spar mining in the Free State. Several licences have already been granted for this in recent years, and initial mining projects are in the exploratory phase.
It is also worth mentioning that many of the raw materials described by a number of studies as "critical" have been found in Saxony, such as indium, rare earths, tungsten, tin, fluorite, lithium, molybdenum and silver.
Saxony is a land rich in raw materials. Solid rock, sand, gravel, all kinds of ceramic materials and lignite exist in comparatively large quantities, and are mined in around 340 locations. Deposits of ore and spar are also available in relatively large quantities compared to elsewhere in Germany. The intensive geological explorations performed across Saxony during the second half of the 20th century have proven to be important sources of information here. In comparison with the rest of the world, there is excellent awareness of the underlying geological situation and individual deposits here, and this can significantly help advance decisions regarding sites and investments.

4.2 Lignite

With its shares in the Lusatian and Central German lignite mining district, the Free State of Saxony is one of the main lignite mining states in Germany.

The approx. 30 million tonnes of lignite mined here every year makes up around 18 percent of the total volume mined across the nation. Constituting about 3.5 percent of the lignite produced worldwide, this quantity is also substantial at an international level. As a comparison, the volume mined annually in Saxony is equal to that of countries such as Serbia, Canada, Romania and India, which rank tenth to thirteenth among the world's top lignite producers.

Saxony's lignite deposits are as follows:

- Central Germany (Saxon part): 13 billion tonnes
- Lusatia (Saxon part): 5 billion tonnes

The lignite supplies likely to be used total approx. 6.7 billion tonnes in Central Germany (Saxon part) and approx. 1.3 billion tonnes in northern Upper Lusatia.

Within the German economy, the lignite industry and its share on the energy market constitutes an important factor for the energy industry and overall economy, with more than 86,000 jobs and numerous upstream and downstream sectors capable of benefitting from the innovation chain of lignite usage.

Reichenwalde open-cast mine
Source: VEM Vattenfall Europe Mining

Until renewable energy developments, network expansion, and energy from wind, solar and geothermal sources can cover the entire base load, lignite will remain an indispensable element for ensuring an independent power supply.

Its cheap, extensive and subsidy-free availability plays a key role here. As such, lignite also helps stabilise electricity prices and secure Germany's position as an economic hub.

In the context of German and European climate-protection targets in Germany for 2020, lignite does its bit towards achieving significant energy-saving potentials and reducing the environmental impacts of fossil energy production by virtue of its role in efficient construction and as a substitute at power plants. The Brandenburg, Saxony, Saxony-Anhalt and North-Rhine Westphalia state governments are focusing on highly innovative technologies to reduce the CO_2 emissions generated through lignite use – usage which consequently plays a key role in maintaining sustainable jobs and creating value regionally.

The guiding vision associated with sustainable lignite use is, however, to further develop from solely thermal to material use of lignite and its components. This is also expected to generate synergy effects when developing relevant thermochemical conversion processes, such as gasification and pyrolysis, for material use of biogenic secondary resources in high-quality products (e. g. biofuels, chemicals or electricity). The chemical industry's material processes will continue to need a carbon source, which, in regions with limited biomass potential – like Europe –, can only be in fossil form when it comes to large-scale technical production. Carbon chemistry provides a unique opportunity for Europe to obtain this carbon from local sources, and thus reduce the unilateral dependence on oil and gas imports. This will ensure potentially greater value creation, and possibly additional opportunities for growth, employment, and the long-term survival of chemical facilities in eastern Germany.

Central Germany in particular enables material carbon usage to be integrated into the structures of chemical parks built in the last 15 years, and whose proximity to sources constitutes a key locational advantage. The "Innovative lignite integration in Central Germany – ibi" project funded by the German Federal Ministry for Education and Research has adopted a promising approach. Initially designed with a regional focus on Central Germany, it seeks to establish a research initiative at a European level – and this development is also being promoted in Saxony.

4.3 Pit & quarry natural resources

The main focus of the Saxon mining industry is on rpit & quarry natural resources, as evidenced by the 345 companies operating in this sector. These companies are responsible for mining almost all the raw materials necessary for the regional construction industry. Over half the active mine sites extract sand, gravel or gravel sand, while the sites mining hard dock, including carbonate rocks, make up around a third of all producers. The rest is primarily spread over cohesive resources such as loam, clay and kaolin. Bentonite is not currently mined in Saxony.

Saxony has many different uses for its pit & quarry natural resources, and these can be divided into three groups:

(1) Hard rock, such as sandstone, gneiss and granite, is used as dimension stones or processed into bulk goods.
(2) Sand and gravel serve as concrete aggregate, anti-frost layers or drainage layers, or are used in road-building or glass-manufacturing.
(3) Clay is used as a base material for bricks (loam), for all kinds of ceramic products (clay), paper, dyes and porcelain (kaolin).

Saxony currently has approx. 30 different mining companies specialising in natural ashlar, which is essentially used in structures whose design and execution are primarily defined by aesthetic, technical and economic aspects. The use of local natural ashlar has a long tradition in Saxony. Local ashlar is indispensable when it comes to constructing buildings and squares and preserving historic building fabric for heritage structures. The natural ashlar resources have made Saxony home to several stone-quarrying and processing centres, whose products have gained prominence at a national and even international level. Bulk goods are used as aggregates for asphalt and concrete, as well as in road-building, rail engineering and civil engineering.
Europe's first porcelain was manufactured out of Saxon kaolin 300 years ago, and the Elbe sandstone used to reconstruct Dresden's Frauenkirche is building material coveted right across Germany. Modern concrete structures, meanwhile, rely on sand and gravel (and limestone). All this demonstrates how indispensable mineral resources are in our everyday life.

4.4 Ore and spar

The worldwide need for ore as a result of increasing demand and reduced or more cost-intensive development of new deposit sites has prompted a massive rise in raw material prices since 2003.

Figure 3
Price trends for selected metals

Source: BGR, 2012

The ore and spar deposit sites in the Ore Mountains were, until very recently, an important basis for Saxony's industrial development. Excavations sparked innovations in mining, metallurgy, and the geosciences of mineraology and geology, extending well beyond the state's borders.
While mining, particularly for tin, uranium, fluorite and barite, ceased with the 1990 economic restructuring, dramatically increased global market prices have been generating considerable interest in Saxony's supplies and the resumption of mining since 2005. An initial mining project focusing on fluorite and barite is already in its technical implementation phase, with further projects currently being planned.
Most of Saxony's ore and spar deposits are located in distinct distribution areas or mining regions in the Ore Mountains and the Vogtland. Other deposits can be found near Schleife and Weisswasser in Lusatia (North Sudeten Basin), north of Leipzig (Delitzsch Granodiorite Massif), and the central Saxon hills (Granulite Mountains). Additional, similar sites and deposits are particularly located at greater depths (>500 m).

The following table shows an overview of the proven geological deposits of metals and spars in Saxony compared to worldwide reserves and global production:

Raw Material	Proven deposits in Saxony (ore & spar – LfULG database)	Global mining production, 2010 (WEBER et al., 2012), USGS, BGS, BGR	percentage proven Saxon deposits out of total global production in 2010	Proven deposits worldwide, 2010 (USGS, BGS, BGR)	percentage proven Saxon deposits out of proven global deposits (reserves)
Aluminium	22,947,550	41,295,381	55.6	uq	uq
Arsenic	55,070	64,132	85.9	N/A	N/A
Barite	1,070,650	7,920,735	13.5	240,000,000	< 1
Bismuth	14,295	9,303	153.7	320,000	approx. 5
Lead	317,170	4,144,495	7.7	85,000,000	< 1
Boron	6,473	4,984,828	0.1	210,000,000	< 1
Cadmium	1,051	23,138	4.5	640,000	< 1
Iron	578,172	1,273,301,060	0.0	80,000,000,000	< 1
Feldspar	0	21,891,325	0.0	N/A	N/A
Fluorite	2,820,617	5,909,912	47.7	240,000,000	approx. 1
Gallium	7	70	9.8	N/A	N/A
Germanium	2	59	3.9	> 450	< 1
Indium	240	609	39.4	N/A	N/A
Copper	161,531	16,114,127	1.0	690,000,000	< 1
Lithium	33,000	44,914	73.5	13,000,000	< 1
Molybdenum	3,017	250,314	1.2	10,000,000	< 1
Nickel	12,435	1,528,766	0.8	80,000,000	< 1
Rubidium	46,000	N/A	N/A	N/A	N/A
Scandium	282	N/A	N/A	N/A	N/A
Silver	354	22,617	1.6	530,000	< 1
Uranium	3,933	53,671	7.3	2,800,000	< 1
Tungsten	53,849	78,551	68.6	3,100,000	2
Zinc	485,088	12,409,028	3.9	250,000,000	< 1
Tin	486,791	319,739	152.2	4,800,000	10

N/A = data not available
uq = unquantifiable
BGR = German Federal Institute for Geosciences and Natural Resources
USGS = United States Geological Survey
BGS = British Geological Survey

While most of Saxony's deposits may be classified as small or average in size in a global comparison, they can play a new economic role in the event of growing demand and rising global market prices. Of particular interest are tin, zinc, copper, tungsten, fluorite, barite, and other metallic resources existing in profitable supply.
Metals and industrial minerals existing in Saxony and deemed important in terms of quantity or value can be used in a number of ways in all kinds of industries:

Raw materials proven to exist in Saxony	Applications
Lead (Pb)	Rechargeable batteries, alloys, radiation protection
Fluorite	Flux in the metals industry, base material for all fluorochemistry, optics, fillers, impregnating agents
Indium (In)	Solar cells, transparent displays, phototransistors, lasers, alloys, special adhesives, the glass industry
Copper (Cu)	Electric conductors, pipes, boilers, coins, fixtures, alloying element for brass and bronze
Lithium (Li)	Long-life rechargeable batteries, normal batteries, flux in aluminium smelting, the glass and ceramics industry, lubricants, pharmacy
Nickel (Ni)	Non-corrosive steel, alloys, metal coatings, coins, gas turbines, catalysts, batteries
Barite	Drilling fluid additive, filler in plastics, soundproofing, pigment (white barite)
Rare earth elements (REEs)	Mobile devices, LCDs, permanent magnets (e.g. in generators at wind power plants), hybrid rechargeable batteries, plasma screens, energy-efficient lamps, glasses, catalysts
Silver (Ag)	Electronics industry, alloys, jewellery, ornaments, tableware, coins, the photo industry
Tungsten (W)	Steel hardeners (tools, plating, bullets), welding electrodes, thermal shields
Zinc (Zn)	Rust protection (galvanising), coins, alloying element for brass
Tin (Sn)	Solder in the electrics industry, tin plates, chemicals, pigments, alloying element for bronze

A wealthy society requires a complex economy with a comprehensive value chain. Even a service-providing society cannot survive without a strong industrial sector. Raw materials mining and industrial production serve as critical guarantors here. Globalisation will not split labour in goods production and distribution to an extent enabling Europe to withdraw from the industrial sectors which impact on the environment. Exiting the raw material economy would lead to loss of knowledge and capacity in the medium term, and increase dependencies. Investment capital would inevitably drain away. All this would critically reduce wealth and social standards. Conversely, scarcity and higher market prices in the face of worldwide demand also need to be utilised to profitably increase domestic mining.
In other words, if mining local resources generates employment and income in the local economy, this must be capitalised on immediately.
The Free State of Saxony supports the current return to ore and spar mining. Exploring deposit sites anywhere always involves financial expense and risk without guarantee of success. The decision to carry out such a project must only ever be made in an entrepreneurial spirit, in keeping with the global market conditions. Although European regulations do not allow aid programmes aimed at funding the establishment of operational facilities, the Free State of Saxony is one of the world's best explored regions from a geological and geophysical perspective. In this respect, it can provide data and services which spare investors the need to engage in tedious, cost-intensive exploration work. With optimised permit and approval processes, it offers legal security over the long term.

4.5 Secondary raw materials – Reclamation potential

In addition to Saxony's primary raw materials, the possibility of reclaiming secondary resources also provides significant potential here. Sorted waste and mixed waste from all kinds of sources are today either reused directly in production processes or treated at recycling plants using innovative sorting and separation technology. Reclamation from secondary resources is becoming particularly relevant among rare earths, given the local industry's extreme dependence on imports in this area.

Saxon recycling industry 2009 (according to the State Bureau of Statistics 2011)

	Total waste disposal	Total waste supplied	for waste removal	for use at waste disposal plants	for recycling plants, secondary resources and products
in [t]	**6,298,729**	**4,007,713**	**179,377**	**2,252,923**	**1,575,413**
Thermal plants	280,557	96,727	4,412	84,115	8,200
Soil treatment plants	434,917	406,806	28,936	370,000	7,870
Chemical/physical treatment plants	390,579	283,102	22,700	226,002	34,400
Scrap-car dismantling plants	95,202	54,191	21	51,381	2,790
Combustion plants with energy recovery	588,507	71,976	534	69,103	2,340
Biological treatment plants	541,858	298,933	7,134	16,631	275,169
Biomechanical treatment plants	436,123	341,992	87,216	233,042	21,735
Shredding and scrapping plants	886,915	902,437	10,957	383,453	508,027
Sorting plants	1,086,919	1,049,764	4,030	599,911	445,823
Treatment plants for electrical and electronic waste	21,752	21,658	591	18,527	2,540
Other treatment plants[1]	505,950	480,126	12,846	200,760	266,520
Waste dumps	1,029,451	[1]	[1]	[1]	[1]

[1] including dumps insofar as the production plants and systems materially recycle waste oil

This strategy revolves around the primary raw materials obtained through mining. As such, the focus is on secondary resources capable of substituting pit & quarry natural resources, coal, ore and spar.
Secondary raw materials from a wide variety of waste (such as scrap wood, used tyres, solvents and municipal waste), and which could replace lignite as an energy source, are not further processed here – largely because their small quantities make them irrelevant compared to other energy sources. Material recycling is generally also the preferred solution over waste combustion for legal, environmental and, increasingly, economic reasons.

4.5.1 Availability and potential for substitution

Secondary raw materials from non-hazardous mineral waste generated through construction, demolition, thermal processes, waste treatment and municipal waste may be used instead of rocks and earth (e. g. bottom ash, boiler ash, filter dust, broken tiles/bricks). The Saxon State Office for the Environment, Agriculture and Geology estimates the quantity of mineral waste in Saxony to be approx. 20 million tonnes, corresponding to almost 50 percent of the annual supply volume of rock and earth (approx. 37 million tonnes). Of this, approx. 40 percent is treated at Saxony's nearly 400 plants, while 60 percent of the mineral waste is poured into opencast mines to make them useable again.

The secondary construction materials are used as aggregate in technical structures (e. g. road-building, industrial estates, soundproof walling), although no secondary construction materials are currently used in structural engineering. Despite their large and therefore highly relevant quantities, secondary construction materials cannot yet replace primary construction materials. The aim here is to more intensively foster the potential of innovative treatment processes and acceptance among users and the public in order to enable secondary construction materials of an adequately high quality to be supplied at competitive prices.

According to nationwide surveys, 92 percent of mineral waste is recycled, covering a third of the demand for these raw materials (Cologne Institute for Economic Research (IW Köln)), and the secondary construction materials substitute 10 percent of the total aggregates used (German Mineral Resources Agency). Metal waste (scrap) and waste containing metal (e. g. slag, dust, packaging) is used to substitute ores and spars. Useable data on substitution potential is only available at a national level (IW Köln, BGR, ZVEI/Commerzbank): almost 50 percent of the crude steel manufactured in Germany is obtained from scrap steel. Scrap is used in around 56 percent of nonferrous metal production. And in Germany's refined sugar and crude steel production industry, 43 percent of the copper, 60 percent of the aluminium, 69 percent of the lead and 44 percent of the crude steel come from secondary raw materials.

The Free State of Saxony has for years been home to established companies providing highly innovative treatment technologies to recover metals.

Findings from the Saxon Bureau of Statistics show that the state's supplies totalled some 917,000 tonnes for a selection of the relevant waste fractions.

EAV-AS	Waste from the iron and steel industry	174,623
10 02	**Waste from the iron and steel industry**	**174,623**
10 07	Waste from thermal silver, gold and platinum metallurgy	602
10 08	Waste from other thermal nonferrous metallurgy	2,025
10 09	Waste from iron and steel-casting	14,017
10 10	Waste from the casting of nonferrous metals	2,474
11 01	Waste from chemical surface treatment and coating of metals and other materials	34,803
12 01	Waste from mechanical moulding processes and processes involving mechanical surface treatment of metals and plastics	442
12 01 02	Iron dust and particles	442
12 01 03	NF metal filings and turnings	647
12 01 04	NF metallic dust and particles	832
12 01 09*	Halogen-free processing emulsions and solutions	31,907
12 01 14*	Processing slurry containing hazardous substances	478
12 01 15	Processing slurry, except those classified under 120114	1,025
12 01 16*	Blasting-agent waste containing hazardous substances	876
12 01 17	Blasting-agent waste, except those classified under 120116	809
12 01 18*	Metal slurry containing oil (abrasive, honing and lapping slurries)	1,497
12 03	Waste from water and steam-degreasing (except 11)	761
16 01	Various scrap vehicles (including mobile machinery and waste resulting from the dismantling of scrap vehicles and vehicle maintenance)	
16 01 17	Ferrous metals	43,770
16 08	Used catalysts	15,614
17 04	Metals (including alloys)	523,888
19 10	Waste from shredding metal-containing waste	
19 10 02	NF metallic waste	280
19 12	Waste resulting from the mechanical treatment of waste (e.g. sorting, crushing, compacting, pelleting), not elsewhere specified	
19 12 03	Nonferrous metals	23,038
Total	**All metal waste / metal-containing waste**	**916,543**

Optimised statistics for the quantities recorded among plant operators and customers would likely show a higher potential for recyclable waste. The Saxon State Office for the Environment, Agriculture and Geology (LfULG) has calculated 7,500 tonnes/year or 1.4 kg/inhabitant/year in unused potential for metal-containing waste generated by private households (e. g. lightweight packaging, residual waste, excluding bulky items). By introducing a yellow bin for non-packaging made from similar materials, Germany is expected to unlock a potential equal to 7 kg of similar-material products per head, per year (570,000 tonnes annually). Further potential can be unlocked if metal-containing mineral waste (e. g. dust and slag) generated during metal recovery continues to be used. Until now, due to lacking profitability, it has primarily been used as a substitute construction material at waste dumps, or been dumped itself.
Rare earths and precious metals are found in a variety of production waste, consumables waste (e. g. electronic and electrical waste), used batteries, scrap vehicles, and large-scale applications such as solar panels or wind turbines. One tonne of disused exhaust emission catalysts can generate 0.5 kg of platinum metals, and one tonne of mobile-phone scraps can produce up to 340 g of gold. This substitution has already reached a substantial scale in some cases (e. g. secondary metals from catalysts, electronic scraps etc. already cover more than half of global demand for platinum metals and palladium). But there is still considerable need and potential for optimisation, particularly for rare earth metals and precious metals.

4.5.2 Improving the knowledge base

The knowledge base necessary to assess the specific, available raw materials potential to be gained from the Saxon economy extracting secondary resources must be improved. When it comes to pit & quarry natural resources, a material flow analysis for both secondary and primary construction materials is essential in order to create optimum conditions for sustainable raw material usage. This requires clarifying questions such as:

- Which secondary raw materials available in Saxony can quantitatively and qualitatively be used to substitute primary raw materials?
- What specific quantities of recyclable waste are generated in Saxony itself, or can be acquired from external sources?
- To what extent can Saxon facilities be expanded/new facilities be set up to treat this waste?
- What technologies are available/must be developed, and, if applicable, how must these be funded?
- What factors need to be taken into account (e. g. demographic change, economic activity, market barriers, environmental framework and approval requirements); Can these be managed or configured in order to achieve the raw material targets?

Stock-takes of this kind have so far been subject to statistically strict limits, including by the framework set by the Environmental Statistics Act. No other regular surveys are conducted in Saxony. Waste quantities recorded for commercial and industrial fields in particular are sketchy at best. The fact that there is no specially "classified economic sector" makes it difficult to gain a comprehensive overview of the Saxony-based companies and plants operating in the secondary raw material economy.

A specific distinction from other industries and between companies actually implementing recycling processes and providing associated services (e. g. recording, transportation) or the necessary technology is urgently required.

Coupled with this is the fact that many companies have dual fields of activity (e. g. mining mineral resources while simultaneously accepting, treating and recycling mineral waste). The register of waste disposal plants in the Free State of Saxony (www.abensa.de) contains 836 facilities. While permitted plant capacities provide some indication of the raw material potential (e. g. capacity for 173,000 scrap vehicles and 78,000 tonnes of electrical waste per year), the available data for this is from 2007. Information on specific, reclaimed materials or material fractions is indispensable when it comes to assessing economic development potential. State government initiatives will also help organise networks for co-operations, knowledge transfer, and joint product and process technology developments.

If nothing else, improving the knowledge base includes a complex, comprehensive study of entire value chains, and this is further impeded by interdependencies between primary and secondary resource flows (e. g. rehabilitation obligations for mining primary raw materials – corresponding flows of secondary construction materials intended for fills, corresponding removal of material for better quality treatment). Comprehensive analyses of material flows are required in order to devise solutions suitable for the overall economy.

There is thus a general need to collect information on the latest supplies, disposal facilities, and secondary resources actually available.

4.5.3 Legal framework conditions and competition

It is worth noting that the work associated with extracting secondary raw materials involves intense regulatory controls compared to mining primary resources. This ranges from concrete specifications in the individual usage stages and processes (e. g. extent of draining or dismantling of scrap vehicles or electrical waste), to target usage quotas, to extensive requirements for analyses and sampling, and not least concrete criteria for determining when a product is no longer waste, and mandatory regulations for manufacturing new materials or products (e. g. EU chemical law). The waste framework regulations implemented through the Closed-Loop Waste Management Act have provided initial ideas for obtaining more raw materials from waste, but these need to be intensified. This comparatively tight legal corset limits leeway for flexible solutions and innovative developments. The state government is always focused on ensuring balanced regulations at an EU and national level, which take into account both environmental requirements and raw material targets. Unlike for primary resource mining, the disposal market also traditionally sees private companies pitted against the municipal authorities as waste management utilities. Insofar as waste provision obligations apply, private companies are initially denied access to this waste. These companies are dependent on the collection procedures of public waste management utilities (e. g. electrical waste) or are bound to the additional specifications stipulated by the public waste management utilities as their clients. But waste is becoming less of an environmental hazard and more of a solution for raw material supply shortages. Given that the process of reclaiming resources, particularly metals and rare earths, from waste involves highly complex procedures and investments in high-tech systems, it pushes the limits of municipal capabilities. Regardless of clear framework regulations and controls, this field clearly belongs to the private economy. Reorientating it requires getting all stakeholders onboard, and exhausting legal capacities at a national and EU level. The amended Closed-Loop Waste Management Act does not meet these needs.

4.5.4 Technological and logistic challenges

Even more so than for mineral waste, recovery processes for metal-containing waste face the tremendous challenge of tackling elaborate material compounds, hybrid component structures, the wide range of materials per product, and correspondingly complex, non-homogenous waste flows. A broad range of options exists for researching and developing innovative processes which maximise potential and prevent system losses for secondary raw materials through irreversible changes. One of the greatest challenges associated with mineral-based secondary resources lies in developing technologies which enable adequately high quality at competitive prices compared to the primary construction materials, and establishing an effective quality assurance scheme. Logistics is another area providing considerable potential for optimisation: For example, waste collection must be optimised for subsequent recycling processes/uses to ensure certain options are not discounted right from the outset. This requires an appropriate information exchange between stakeholders in the value chain (manufacturers, suppliers, consumers, recyclers).

Additional value can be created by ensuring the technical know-how acquired through treating and processing primary resources can also be used for secondary raw materials. Experience to date shows that corresponding technological synergy effects are principally anticipated in relation to coal (technologies associated with the material usage of lignite, e. g. gasification, pyrolysis), ore or spar (selection and smelting using recovery technology processes). The creation of networks, as well as researching and conducting training to develop and secure connections between the production of primary and secondary resources, pose particular challenges for the future.

4.5.5 Waste exports

The exporting of metal-containing waste in particular (e. g. scrap, electrical waste, scrap vehicles), which does not undergo any high-quality recovery processes in the importing country, results in large quantities of secondary raw materials being lost. Around half of these are illegal exports from the EU. But even legally exported waste prevents secondary raw materials from accessing the German economy through unreliable re-importing options. As such, fewer than 50 percent of rejected vehicles are reused in Germany.
EU regulations should eliminate the ongoing uncertainties associated with distinguishing between waste and functional products (already in existence for some electronic devices). This will cut out legal grey areas which otherwise encourage illegal exports. Framework conditions which either make domestic recovery processes more attractive than exports, or which ensure high-quality recovery abroad, with the option of re-importing the secondary resources, also need to be created.

4.5.6 Reclaiming rare earths

Rare earths are frequently widespread and exist in very low concentrations. During conventional recycling processes, they end up irretrievably lost in shredder fractions or waste combustion. Instead of processes aimed at mass metals (recycling quotas), there needs to be efficient collection systems and treatment techniques which can be used to reclaim the small percentages of high-quality elements. And these must be perfectly co-ordinated. If, for example, only 50 percent of the used products are collected, even a 95 percent recovery quota in a high-tech process will be unable to compensate for the losses incurred during collection.
Recovering rare earths requires specific know-how, complex processes (especially chemical processes) and elaborate equipment. Very few systems and technologies around the world have so far been capable of this. Self-developed recovery processes are often not profitable for commercial use due to the great time and expense involved with dismantling, and the intense energy requirements. Research and development in this area are particularly important, as is the need for financial support (very large, risky investments). The Free State of Saxony must acknowledge and foster the resulting opportunities provided by a new, meaningful high-technology industry. A critical initial step has been taken with initiatives such as the "Life Cycle Strategies" innovation forum in Freiberg and the research activities performed by the Helmholtz Institute of Resource Technology, Freiberg. Saxon companies can be supported in their efforts to develop new, highly effective recovery and treatment technologies and associated specific machinery, systems and equipment, including in co-operation with university or non-university research institutes, as part of Saxony's technology funding programme.

4.6 Geothermal energy

Geothermal energy is gaining prominence as a renewable energy source, and harbours considerable potential for environmentally friendly energy use, including for Saxony, given the current situation in the raw material and energy industries. Geothermal energy, which is located close to the surface and also covers mine-water geothermal energy, unlocks potential to depths of 400 m, and is used exclusively for climate control in buildings. Shallow geothermal energy currently operates approx. 900 geothermal power plants in Saxony, with an installed total heat output of approx. 107 MW. Saxony's flooded mining caverns provide a previously underused potential for climate control (heating and cooling) in buildings. Current cases of geothermal energy being used in Saxony can be found in Marienberg (aquamarine), Ehrenfriedersdorf (secondary school), and Freiberg (Schloss Freudenstein, Steigerhaus Reiche Zeche). Deep geothermal energy is one of the environmentally friendly future prospects for power and heat generation. Unlike other states, Saxony's geology means only petrothermal energy can be used. Temperature models reveal values between 105 and 190°C at depths of 5 km. Generating power by drilling to depths of 5 km to use the energy stored inside the earth appears to be a feasible option in Saxony in almost all of the areas examined.

5. Raw material expertise as the basis for a modern economy

Having broad expertise in raw materials can make Saxony a leading innovator in the field. Business and scientific capacities provide unique potential for sustainable value creation in the Free State of Saxony, and enable good opportunities for development. Saxony has excellent expertise and substantial capacities in research, business and administration, covering the entire life cycle from raw material mining, to treatment, refinement and processing, to reclamation. As Germany's engineering hotspot, the state is able to provide qualified workers to meet companies' needs for specialists and managers. Additional expansions in Saxon raw material research helps ensure it retains its top position at an international level. Of equal importance is Saxony's scientific know-how and business acumen in the field of materials research. New materials gained as a result of reclamation or substitution will replace or supplement traditional materials. This involves changes in manufacturing processes, tool and machinery requirements, and thus mechanical engineering innovations.

Freiberg is Saxony's scientific hub for geoscientific, geotechnical and geo-economical matters, land-use planning, regional planning, resource usage/safeguarding, and economically sound usage of the geosphere. A number of establishments and initiative exist for this purpose. The **Freiberg University of Mining and Technology**, as Saxony's university specialising in resources, teaches and researches in four main fields – geosciences, materials, energy, and environment – along the value chain to facilitate sustainable materials and energy industries. Since its founding in 1765 as the world's oldest mining university, it is closely affiliated with mining and the metallurgical treatment of mineral resources. Its scientists are not only focused on uncovering new deposits, but also on developing alternative energy technologies, new materials, and modern recovery processes.

The plans to extend the existing "Reiche Zeiche" educational and research mine, in close co-operation with the Helmholtz Institute of Resource Technology in Freiberg, into the world's first "green" mine are also set to reinforce and further develop the very successful approach of horizontal networking through the raw material value chain and vertical networking of the idea through laboratory testing and the pilot plant. In consultation with Saxon, German and international research partners and industrial companies, they also aim to develop and test methods and processes which operate efficiently in terms of raw materials, the environment and resources to sustainably obtain raw materials under in-situ conditions. **Freiberg's Helmholtz Institute** of Resource Technology, sponsored by the Freiberg University of Mining and Technology and the Helmholtz Centre in Dresden-Rossendorf, pools research expertise to ensure the German economy can be adequately supplied with raw materials. One of the initial main tasks is to mine and recover high-technology metals such as gallium, indium, germanium and rare earth elements, which are indispensable in the fields of renewable energy and electromobility.

Founded on 1 July 1542, the **Saxon Mining Office** is Germany's oldest mining authority, and was the key source of the mining-law developments which were then applied in other mining regions of Europe. The term "sustainability" was coined by chief mining administrator Hans Carl von Carlowitz as early as 1713, and, since 1991, the Saxon Mining Office has been the competent authority for occupational health and safety, environmental protection, and resource sustainability in Saxony's mining industry. It concentrates primarily on open-pit mining for lignite, pit & quarry natural resources, as well as land rehabilitation and an old mining tradition spanning centuries.

The Bergarchiv Freiberg stores and preserves official Saxon mining and metallurgical documents and mining company documents dated up to 1990. Its archives provide insights

Reiche Zeche in Freiberg | Source: Heymann – SMWA

into mines and underground caverns, revealing information on deposits, safety issues as part of old mining projects relating to exploration and storage measures, and the impacts of mining history on Saxony as a region.

Saxon Geological Survey is performed by the **State Office for the Environment, Agriculture and Geology**. Based in Freiberg, the Geology department is the central port of call for applied geoscientific matters such as resource geology, hydro geology and engineering geology. Calculating Saxony's resource potential, including all deposits and supplies, enables important technical bases to be established for studies and analyses in resource geology. Other tasks include geological surveying and assessing geological risks such as earthquakes. The State Office for the Environment, Agriculture and Geology acts as the main authority here for administrating and providing all geological data (e.g. drillings and other exploration), and this information plays a major role in the lead-up to business activities aimed at exploring raw materials.

Additional research establishments in Freiberg, such as the Fraunhofer Technology Centre for Semiconductor Materials, non-profit research institutes, and private companies round off the knowledge and performance capacities across all aspects of mining.

The **Geokompetenzzentrum Freiberg e.V.** was founded in March 2002 with the direct involvement of the Free State of Saxony. It is a network of more than 170 members from business, science and administration, pooling the region's varied expertise in the fields of geology, the environment, mining, and the extracting and recovery of raw materials. The centre's primary focus is on developing new quality in the issue-driven collaboration between science, research, administration and business, while interdisciplinary work groups from members' and partners' fields formulate requirements for the market or project.

The co-operation between state institutions and businesses from the relevant industries combines the existing capacities for further research and development. The businesses are offered state partners to provide scientific assistance for projects. The Freiberg University of Mining and Technology, the Mining Office, and the State Office for the Environment, Agriculture and Geology all have access to practical research and information from other mining regions – a concept which must be constantly deepened and developed into a central hub for geosciences and mining.

6. Technology transfer – What can Saxony offer?

Framework agreements and supply contracts are just one important step towards accessing and using other nations' raw material stores. They cannot guarantee protection against commodity market distortion on their own. Regardless of the resources available, many countries take measures to manipulate price trends, protect their own industry, and control exports. On the other hand, Third World countries in particular lack the experience and knowledge to efficiently mine their raw materials. Only with increasingly mutual networking can mutual trust and insight into common interests grow. This requires intense cultivation of business and contacts at all levels.

Saxony's mining companies and experts boast impressive knowledge and experience here. The state has a centuries-old tradition and latest knowledge of the raw material economy, making it highly regarded in resource-rich countries, especially in Africa, Latin America and Asia. Its experience in the complex field of ore mining, sustainable mine rehabilitation, and expertise in alternative excavation methods, smelting and resource reclamation in particular is gaining in demand worldwide.

Saxony is a hub for geoconsultants, exploration companies, active mining companies, and highly specialised firms operating in the area of mine rehabilitation. Saxony has an efficient, powerful raw material economy with some 5,000 companies employing around 75,000 staff.

In addition to the companies mentioned above, Saxony is also home to a number of firms supplying the technology required to extract and treat raw materials. Many businesses have purposely established bases near the Freiberg University of Mining and Technology in order to collaboratively develop new machinery, system technology and treatment processes. Highly complex open-cast mining systems from Saxony – ranging from bucket-wheel excavators to bucket dredgers to conveyor bridges – transport raw materials around the world.

Companies operating in the fields of environmental and reclamation engineering with leading innovative technologies, particularly for recovering ferrous and nonferrous metals from various types of waste, have established themselves in the Freiberg region, based on the raw materials industry which has emerged there.

The region also serves as the hub for a strong industry with a growing demand for strategic raw materials (e. g. photovoltaic industry, supply industry for microelectronics, foundry industry etc.).

International co-operations make state institutions open to raw material-rich countries seeking long-term collaborations with German companies, both as research centres and training centres for their specialists. This lays the foundation for ongoing partnerships and co-operations extending beyond single projects.

7. A need for skilled labour

Studies and training in mining professions have a long tradition in the Freiberg region as a result of its 800-year mining history. In order for the area to be further developed, companies' needs for skilled specialists and managers must be reliably met. This will be one of the biggest challenges over the coming years.

Raw material production in particular requires training and practice to be closely intertwined. The **Freiberg University of Mining and Technology** is one of Germany's three classic training institutions for young students of the extractive industry. Its results in rankings and external funding consistently demonstrate a high quality of research and teaching. Its solid profile has given it top future prospects in a highly competitive university landscape, and seen it continuously grow every year. The Freiberg University of Mining and Technology is today Germany's only university to offer training options in all mining and geosciences subjects. Its seven institutes provide a comprehensive package of Bachelor and Masters courses under one roof:

- Mining and specialised foundation engineering,
- Drilling technology and fluid mining,
- Geology,
- Geophysics,
- Geotechnics,
- Mine surveying and geodesy, and
- Mineralogy

The Freiberg University of Mining and Technology also offers a number of training options in the recovery of secondary resources from waste (e. g. "Chemistry and physics", "Mechanical engineering, process technology and energy engineering", "Materials engineering and technology") at several of its faculties.

This is supplemented by the services at the nearby **TU Dresden**, particularly in its science and engineering faculties (e. g. Institute for Waste Management and Contaminated Sites, Chemistry Department, Institute for Process and Environmental Technology, and the United Nations University Institute for Integrated Management of Material Fluxes and of Resources (UNUFLORES), specialising in the secondary resources industry).

In anticipation of a revival in Saxon mining activities, mining training courses have been offered since 2004 through a joint initiative by the Saxon State Ministry for Economic Affairs, Labour and Transport, the **Technical College at the Julius Weisbach Vocational Training Centre**, and the State Mining Autority of Saxony. Germany's only recognised trade of miner and mining machine operator provides graduates with excellent opportunities to join the profession and start their career.

The **State Mining Autority of Saxony** is the supervisory authority appointed by the state government for the course, and has for many years been continuously training aspiring teachers preparing for higher civil service. This training is offered in the subjects of mining and surveying. The preparation phase is geared around subsequent employment in the state mining administration. The knowledge acquired also opens up a number of opportunities to work at companies in and outside of the mining industry. For qualified surveying engineers, successfully completing the preparatory phase simultaneously serves as a basis for becoming a recognised surveyor later on.

The traditional Beflissenenausbildung or training for registered mining students sees geoscience students learn practical mining and surveying skills and knowledge from a variety of mining sectors to equip them for subsequent employment.

The various training options offered by vocational colleges and universities in Saxony are not just designed to meet the local demand for young talent. They can also include training for students from other countries in need of skilled labour.

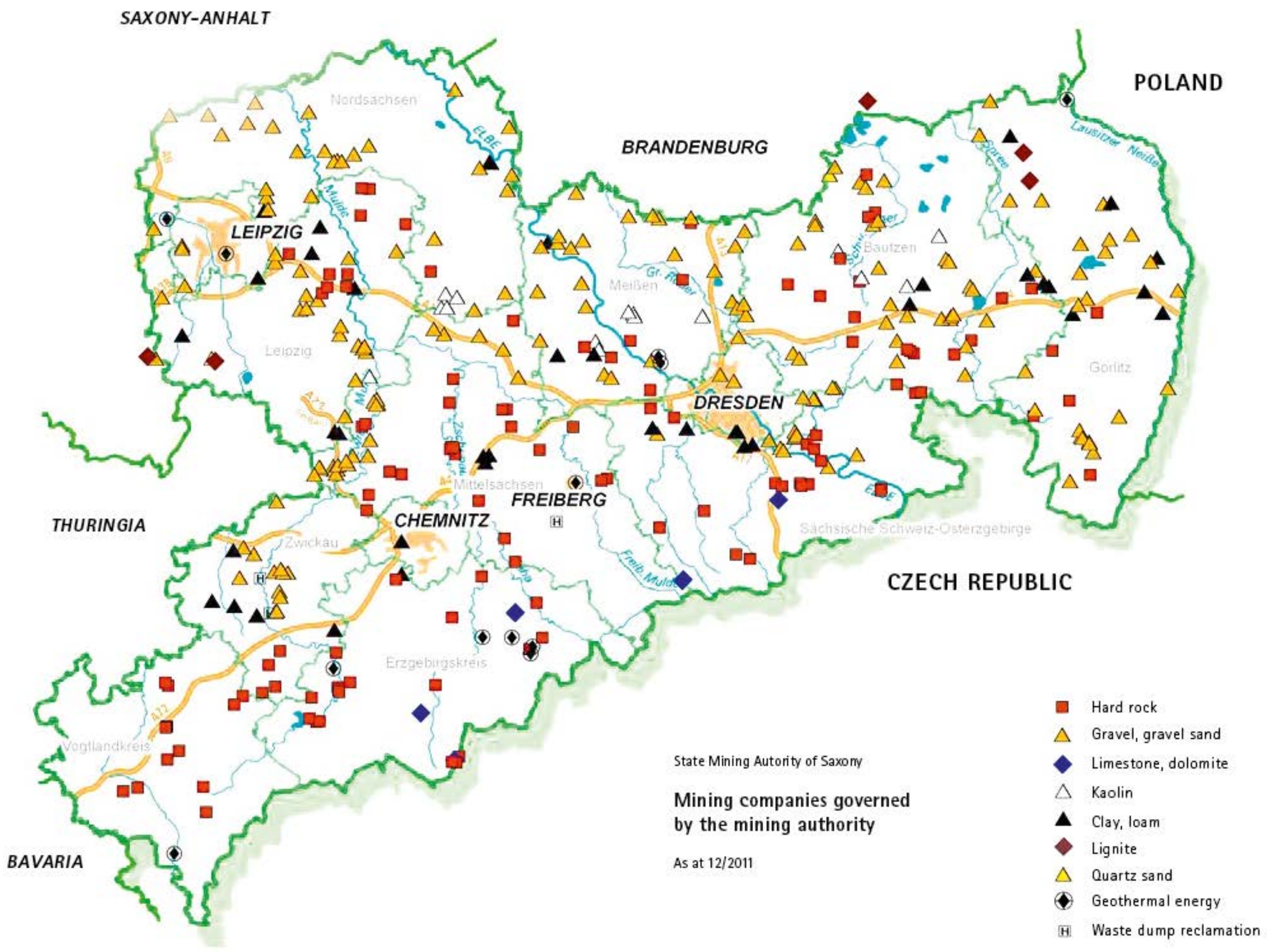
The Saxon raw material economy plays a key role in the Saxon economy. Saxon raw material policy aims to permanently strengthen the state as a raw material hub, increase opportunities for value creation in this important sector, and help ensure a sustainable supply of raw materials for Saxony's growing industry. To do this, the Saxon state government follows the guidelines below.

8. Guidelines and objectives of Saxon raw material policy

8.1 Local primary raw material: Saxony as a land of mining

Saxony will continue to be a land of mining. As such, the framework conditions for mining local raw material must ensure remains profitable over the long term:

- By having land-use plans which protect regions potentially capable of being used to mine mineral resources and lignite,
- By systematically updating existing raw material databases,
- By helping companies finance deposit site exploration, and
- By adapting the legal framework conditions to the needs of the raw material economy.



Source: State Mining Autority of Saxony Freiberg, Mine Surveying

8.2 Secondary raw materials: Saxony as a land of secondary raw materials

Saxony is becoming a land of secondary raw materials. As such, the framework conditions for ensuring the resources contained in waste are reintroduced to the materials cycle must be further developed to enable Saxony to become a leading hub for the reclamation industry in Germany and Europe:

- By improving the knowledge base for Saxon companies to assess specific, feasible secondary resource potential derived from waste,
- By paying greater attention to the raw material targets in recycling law,
- By increasing the quantitative and qualitative (e. g. rare earths) material usage quota in waste disposal,
- By providing the option of reclaiming raw materials from current and future waste,
- By increasing the attractiveness of recovering materially reusable waste within Germany instead of exporting it/by encouraging high-quality recycling processes and the necessary infrastructure (e. g. separate collection) abroad,
- Through better co-ordinated collection and recovery processes based on networked expertise in the base-material-processing industry and recycling industry,
- By helping to research and develop new separation and treatment technologies, and develop specific mechanical and system technology
- By supporting innovations and investments in the field of resource recycling, particularly for high-technology processes and systems designed to recycle rare earths
- By strengthening competition in the disposal industry, and
- By raising social perceptions of the recycling industry as part of the raw material economy.

8.3 Saxony as a hub of the raw material economy

The traditional networking between stakeholders of the raw material economy has always been a key foundation and source of scientific and technical progress in Saxon raw material economy. This networking must ensure individual stakeholders are able to benefit from it, and must also encourage innovative developments in the industry:

- By helping expand and pool existing networks, such as the Geokompetenzzentrum Freiberg e. V., FIRE e. V., LIBESA etc.
- By further developing economic and scientific capacities and expertise in Saxony's raw material economy, particularly in Freiberg and Dresden,
- By systematically marketing Saxony as a hub of the raw material economy, and
- By creating framework conditions which encourage additional stakeholders to contribute their potential to existing structures.

8.4 International co-operations

The Saxon raw material economy has long-time international contacts in resource-rich countries. These contacts must be developed in such a way so as to ensure Saxony's expertise in this field can be marketed better than before:

- By cultivating contacts with foreign graduates from Saxon universities, particularly the Freiberg University of Mining and Technology,
- By supporting resource-related partnerships between Saxon universities and international universities and research institutes in selected countries, for both primary and secondary raw materials,
- By supporting Germany's resource partnerships with selected countries,
- By supporting the Saxon raw material economy during activities abroad, particularly as part of the Saxon foreign trade initiative,
- By marketing specific Saxon resource technologies and resource-related research results, and recognised reference objects for mine restoration and rehabilitation, as well as
- By helping partner nations create framework conditions for their national resources industry, based on development tasks and objectives.

8.5 Saxon raw material research

The current technical, economic and environmental challenges faced by the raw material economy require intensive scientific assistance. This means strengthening the existing structures at universities and non-university establishments, networking them closely with one another, and expanding them in accordance with current requirements to make Freiberg a mining hub:

- By gearing the university landscape, particularly the Freiberg University of Mining and Technology and the TU Dresden, around the requirements of a sustainable raw material economy,
- By supporting the establishment of other research institutes, particularly in places where expertise already exists,
- By developing business-related research at companies,
- By intensifying application-oriented resource research at all stages of the value chain, including specific mechanical and plant engineering,
- By creating the nation's and Europe's only research environment for raw material production by developing the Reiche Zeche educational and research mine to become the world's first sustainable mine,
- By more intensively integrating Saxon resource research into European and non-European networks,
- By developing technologies which economically enable the mining, treatment and processing of local raw materials, ensure extensive, profitable recycling of raw materials generated by waste, better network the two fields, and utilise synergy effects, and
- Through effective technology transfer of the specific know-how existing at universities and research institutes, and the relative results, to Saxon businesses.

8.6 Skilled specialists for the raw material economy

The (continued) training of skilled specialists in the field of raw materials is a traditional forte of the Saxon education system. To perpetuate this tradition, Saxon must further develop its leading role in this area:

- By intensifying the (continued) training of local specialists and managers,
- By training foreign specialists and managers, especially those from resource-rich developing nations and newly industrialised nations,
- By intensifying resource-related skills at the relevant Saxon universities,
- By supporting international contacts and projects at the relevant Saxon educational establishments,
- By adapting the training programmes to the relevant needs of the national and international raw material economy, and
- By networking the various education providers.

8.7 Saxon administration

The Saxon administration considers itself a service provider of the raw material economy. Building on centuries-old (in some cases) experiences, the aim is to constantly gear the existing structures around the needs of the raw material economy:

- By maintaining an independent, efficient Saxon mining administration,
- By having Freiberg as the central hub of resource-related administration,
- Through continuous dialogue between the administration and business,
- By efficiently structuring administrative processes, and
- By raising awareness of the raw material economy's interests at all levels of administration.

8.8 Awareness of raw materials

The Saxon raw material economy has traditionally been very well accepted by the public. The idea of working towards an ideology-free, knowledge-based, not fear-based community awareness of raw materials must be established as a task performed by society as a whole:

- By conveying the notion that the raw material economy is one of the essential bases of human society,
- By teaching solid, basic science at all levels of education,
- By systematically teaching facts and practices relating to raw materials to people of all ages and education levels,
- Through an offensive information policy regarding the requirements and opportunities of a modern raw material economy,
- By rehabilitating post-mining landscapes, taking into account both the traditional regional factors, as well as unlocking opportunities for sustainable regional development, and
- By effectively presenting the work already done to rehabilitate post-mining landscapes in Saxony

9. Implementing the Saxon raw material policy

Below is a list of short-term and medium-term tasks which help ensure the guidelines and objectives are implemented.
It must be constantly updated.
The tasks are aimed at all stakeholders in the raw material economy – companies and associations, as well as educational and scientific establishments, policyholders, the administration and citizens.
The purpose of this list is to name/acquire specific tasks and persons responsible for them. Although some tasks serve to fulfil a number of guidelines, we have endeavoured to allocate the specific tasks to certain guidelines.

1. Local primary raw materials: Saxony as a land of mining

Tasks	Stakeholders
Developing a Saxon initiative at a national and European level to financially assist with prospecting and exploring local deposit sites	STG, FI, AS
Updating the databases for Saxon pit & quarry natural resources, spar, ore and lignite resources regardint quantity and quality	STG, LfULG, AS
Fulfilling the raw material data principles in the regional and land-use plan	SMI, RPA
Formulating a plan to back up raw material data currently existing outside the state administration	STG, CMP AS
Providing a representative illustration of Saxony's raw material potential to entice investors and develop and operate a Saxony-specific, resource-oriented information service	AS, LfULG

2. Secondary raw material: Saxony as a land of secondary raw material

Tasks	Stakeholder
Initiating pilot projects to optimise a co-ordinated system to collect recycled materials	STG, PWDA, AS, CMP
Developing quality-assurance systems for secondary raw materials	STG, AS
Analysing potential for profitable, accessible secondary raw material sources	STG, AS
Analysing material flows for the sustainable use of mineral primary and secondary construction materials in Saxony, taking into account reciprocal effects and interactions	LfULG, LD, OBA, STG, AS, CMP, MC
Developing a "secondary raw materials" network for resource users, recyclers and authorities	AS, PWDA, STG, AD
Developing a plan for the future waste-dump industry in order to ensure raw materials obtained from dumped waste can be recycled profitably	LfULG, universities, PWDA, STG

3. Saxony as a hub of the raw material economy

Tasks	Stakeholder
Developing and operating a Saxony-specific, raw material-oriented information service	AS, AD, CIC
Holding events geared around the raw material economy, particularly also for material-intensive and material-sensitive businesses	AS, CMP, GKZ, CIC, TU
Supporting theme-specific networks, e.g. the "Innovative Braunkohlen Integration in Mitteldeutschland ibi" (coal refining), "Life Cycle Strategien" and "Geobiotechnologie und Mikrobiologische Verfahren im Bergbau" innovation forums	STG, CMP, AS, SI, GKZ, PWDA, TU
Updating the Saxon Raw Material Strategy	STG

4. International co-operations

Tasks	Stakeholder
Concluding bilateral agreements regarding Saxony's co-operation with important resource-rich countries (e.g. Mongolia, Namibia, Angola, Mozambique, Vietnam, former CIS states etc.)	STG, AS, GKZ
Creating a programme to internationally market Saxon raw material expertise acquired from research, business, education and administration	STG, TU, GKZ, AS, AD
Pooling the student networks of all resource-related faculties at Saxon universities into one institutional platform	SU, CIC

5. Saxon raw material research

Tasks	Stakeholder
Developing a Saxon "Sustainable raw material use" research programme	TU, HZDR, INST, CMP, SI, STG
Developing practice-oriented raw material research, e.g. through intensified co-operation between science, administration and business as part of grading work	TU, HZDR, CMP, SI, AD
Formulating a plan for targeted, practical staff exchange between business, science and administration	TU, HZDR, INST, STG, CMP, SI, AD
Integrating "Saxon raw material" issues into the work of the Freiberg Institute for Resource Technology	STG, AS, GKZ, TU, HZDR, AD
Pilot projects to increase efficiency in obtaining both local raw materials and secondary raw materials, including networking both fields	TU, HZDR, INST, AS, CMP, SI
Re-appointing chairs for processing, mining and surveying at the Freiberg University of Mining and Technology	TU, STG
Re-appointing a chair for waste management at the Institute for Waste Management and Contaminated Sites at the TU Dresden	STG, TU
Providing focused support for research and development to recycle local raw materials, e.g. coal refinement	STG, AS, TU, CMP, INST, SI
Providing focused support for research and development to sustainably recycle raw materials in a resource-efficient and environmentally-efficient at the Freiberg University of Mining and Technology	TU, SI
Developing the "United Nations University Institute for Integrated Management of Material Fluxes and of Resources" (UNUFLORES) at the TU Dresden	STG, TU

6. Training specialists for the raw material economy

Tasks	Stakeholder
Formulating and implementing (continued) training initiatives for the Saxon raw material economy and research	STG, AS, CIC
Developing mining and raw material training programmes at the Technical College at the Julius Weisbach Vocational Training Centre	STG, CMP, CIC, BSZ

7. Saxon administration

Tasks	Stakeholder
Formulating a continued raw material training programme for affected administrations	STG, EI, AS, AD
Formulating a staff-exchange programme between companies and the administration	AS, STG, AD

8. Awareness of raw materials

Tasks	Stakeholder
Intensifying co-ordinated, raw material economy-related PR across all media	STG, CMP, AS, SI, GKZ, TU, AD
Formulating a plan to develop and increase social awareness of raw materials	AS, STG, GKZ
Developing promotional projects to increase regional acceptance of specific raw material projects	AS, GKZ, CMP, MC
Developing raw material information material for school and pre-school education	AS, EI, STG, GKZ
More intensively incorporating the issue of raw material into basic science teaching at all levels of education	STG, GKZ, EI
Reintroducing the school subject of geography as a specialised course	STG, GKZ

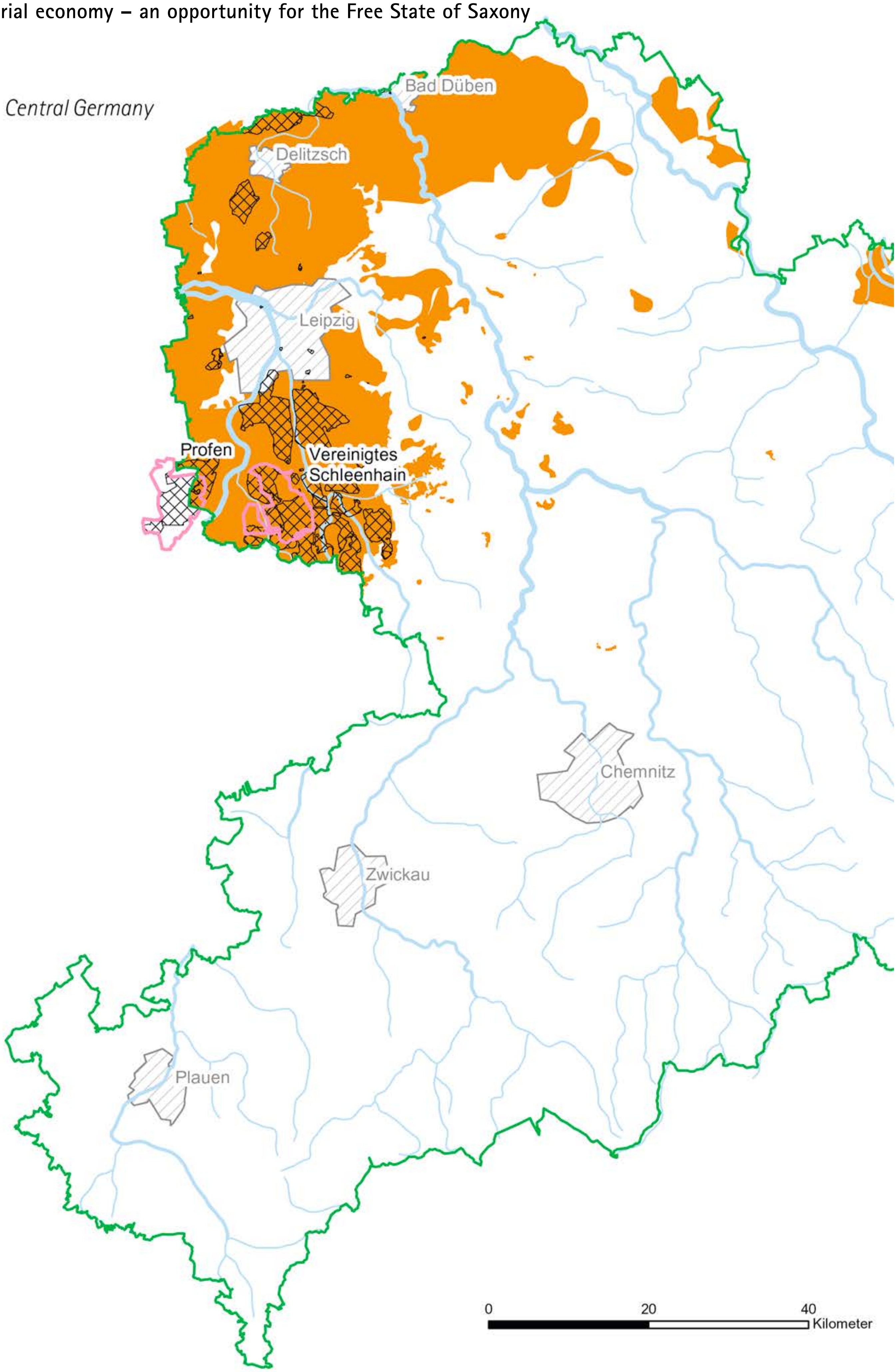
List of abbreviations

BSZ	Berufsschulzentrum (vocational training centre)
EI	Educational institutions
FI	Financial institutes
GKZ	Geokompetenzzentrum e. V.
HZDR	Helmholtz Zentrum Dresden-Rossendorf (sponsor of the Helmholtz Institute Freiberg for Resource Technology)
CIC	Chambers of industry and commerce
INST	Institutes
MC	Municipalities
PWDA	Public waste disposal authorities
RPA	Regional planning associations
SU	Saxon universities
STG	State government
TU	TU Bergakademie Freiberg (Freiberg University of Mining and Technology), TU Dresden etc.
CMP	Companies
AS	Associations
AD	Administration
SI	Scientific institutions
WFS	Wirtschaftsförderung Sachsen

Appendix (maps)

- Lignite in Saxony
- Deposits of pit & quarry raw materials in Saxony
  Mineability assessment
- Ore and spar deposits in Saxony

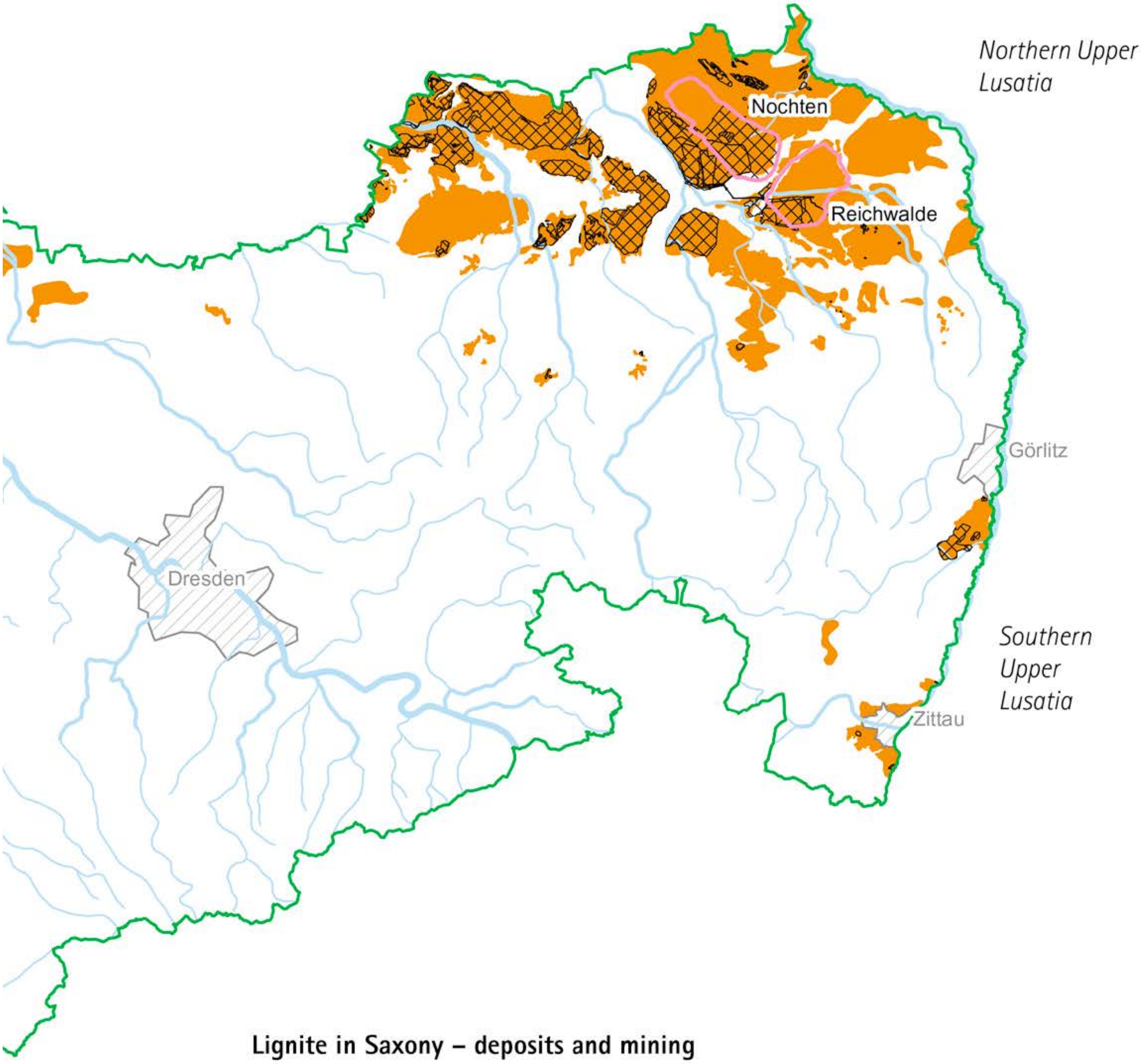
Notes



Central Germany
Bad Düben
Delitzsch
Leipzig
Profen
Vereinigtes Schleenhain
Chemnitz
Zwickau
Plauen
0
20
40
Kilometer

STAATSMINISTERIUM
FÜR WIRTSCHAFT
ARBEIT UND VERKEHR

Freistaat
SACHSEN



Lignite in Saxony – deposits and mining

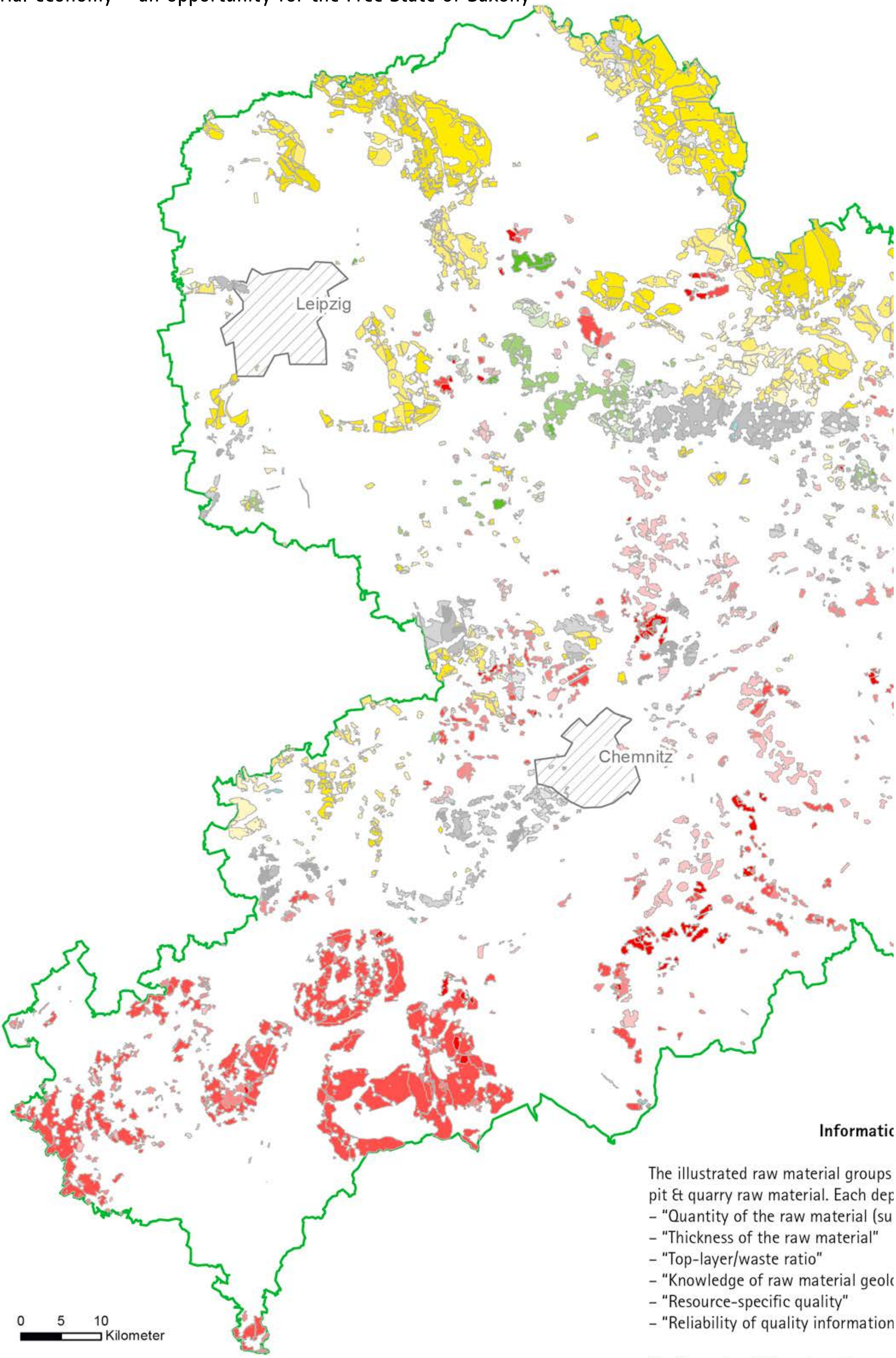
Lignite processing (seam thickness ≥ 2m)
Not shown under the cities of Leipzig, Delitzsch, Bad Düben and Zittau

Open-cast mines (abandoned, restored, exhausted, active mining within the framework operations plan areas)

Nochten — Framework operations plan areas for lignite with open-cast mine name

Southern Upper Lusatia — Name of lignite mining district

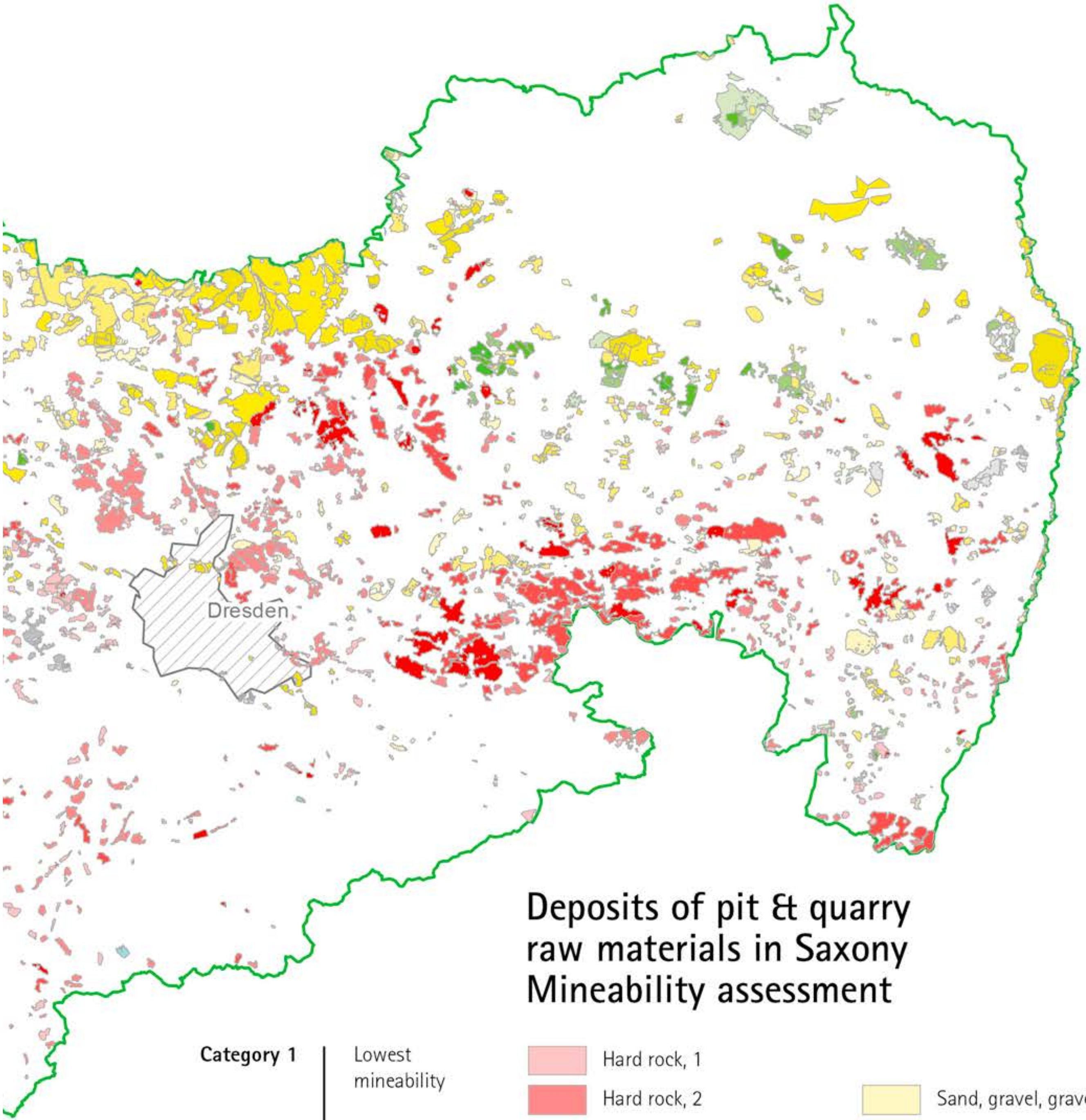
Appendix 1



Informatic

The illustrated raw material groups
pit & quarry raw material. Each dep
– "Quantity of the raw material (su
– "Thickness of the raw material"
– "Top-layer/waste ratio"
– "Knowledge of raw material geolo
– "Resource-specific quality"
– "Reliability of quality information

The four mineability categories are



Deposits of pit & quarry raw materials in Saxony Mineability assessment

Category 1 – Lowest mineability

Category 4 – Highest mineability

- Hard rock, 1
- Hard rock, 2
- Hard rock, 3
- Hard rock, 4
- Carbonates, 1
- Carbonates, 2
- Carbonates, 3
- Carbonates, 4
- Clay, kaolinite, bentonite, 1
- Clay, kaolinite, bentonite, 2
- Clay, kaolinite, bentonite, 3
- Clay, kaolinite, bentonite, 4
- Sand, gravel, gravel sand, 1
- Sand, gravel, gravel sand, 2
- Sand, gravel, gravel sand, 3
- Sand, gravel, gravel sand, 4
- Loam, marl, 1
- Loam, marl, 2
- Loam, marl, 3
- Loam, marl, 4

n on determining mineability

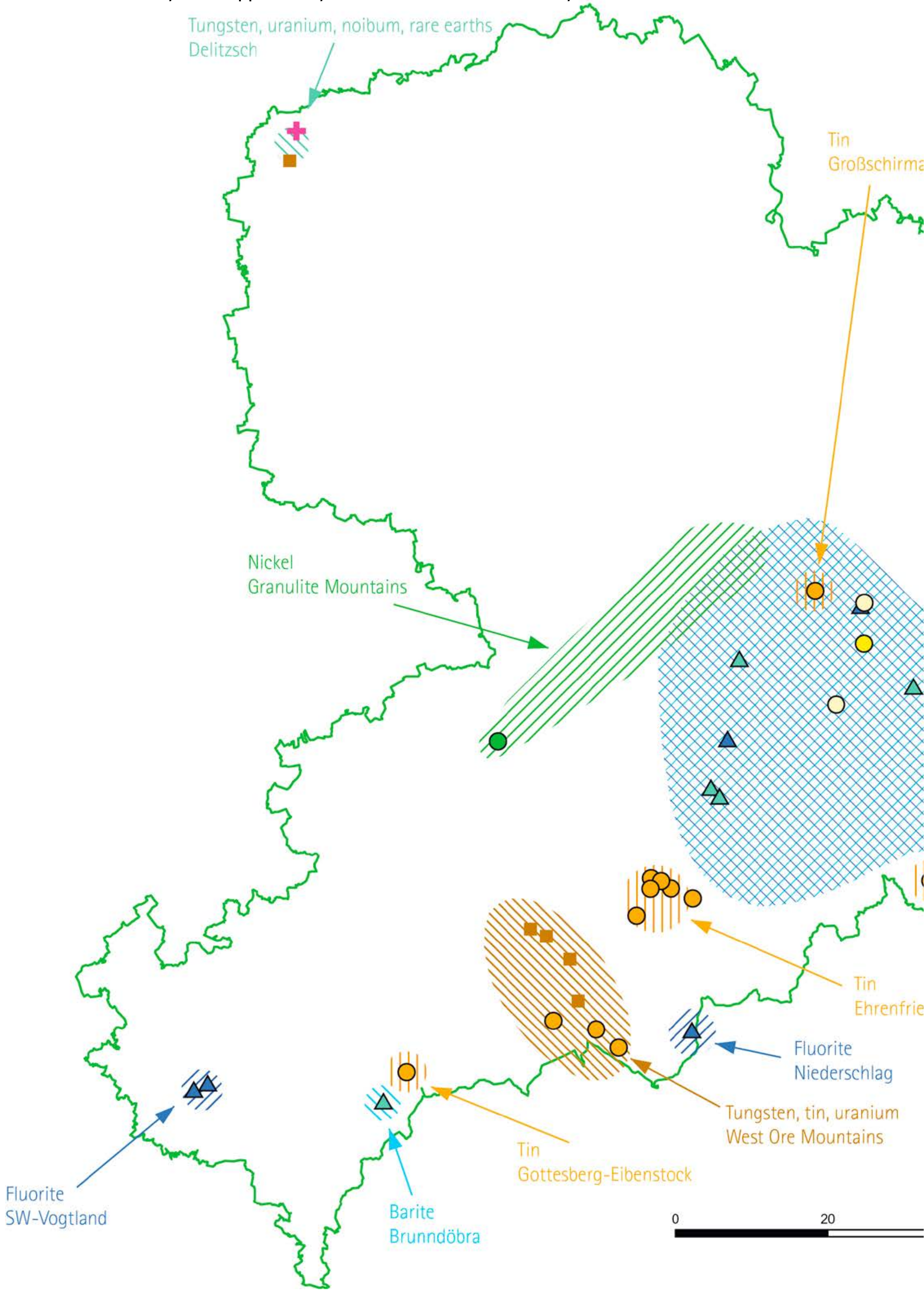
serve as the basis for assessing the deposits of
osit is awarded points using the following parameters:
pply)"

gy"

"

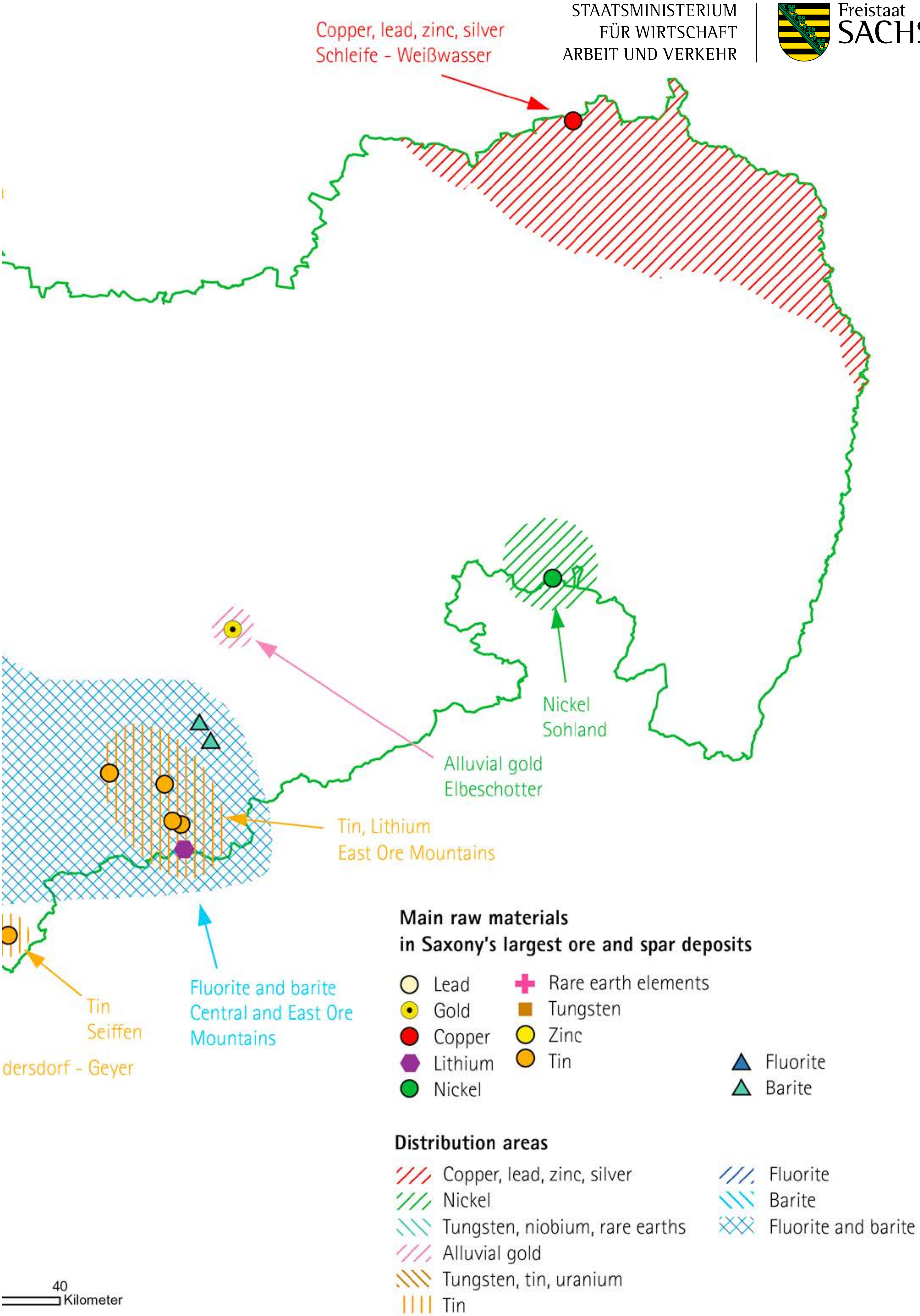
determined based on these, using statistical processes.

Appendix 2


Tungsten, uranium, noibum, rare earths
Delitzsch
Tin
Großschirma
Nickel
Granulite Mountains
Tin
Ehrenfrie
Fluorite
Niederschlag
Tungsten, tin, uranium
West Ore Mountains
Tin
Gottesberg-Eibenstock
Fluorite
SW-Vogtland
Barite
Brunndöbra
0
20

STAATSMINISTERIUM
FÜR WIRTSCHAFT
ARBEIT UND VERKEHR

Freistaat
SACHSEN



Appendix 3

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