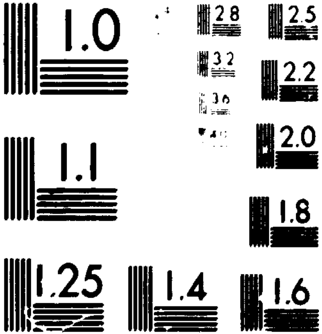

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GEOLOGICAL PROSPECTION AND EXPLORATION FOR NON-METALLIC MINERAL RAW MATERIALS

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GEOLOGICAL PROSPECTION AND EXPLORATION FOR NON/METALLIC MINERAL RAW MATERIALS

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Motto:

"Practically each rock or mineral type on the Earth´s surface can be considered to a distinct degree as a mineral raw material in defined time period with respect to the existing economic conditions of individual country"

Christopher O.Newcome, 1889

These really prophetic words of the past century survive and are still valid in new economic conditions during the last decades of the 20th century. The world search for mineral wealth on the surface as well as for the hidden deposits is growing steadily both in developed industrial countries as in developing and underdeveloped countries. Europe, Asia, North America and Africa are the main continents where classical types of ores and non-metals are being discovered together with new types of mineral occurrencies, but also South America, Australia, bottom of most oceans, Antarctis and also Arctic regions play an important role in search for minerals in future projects.

Classical ore disctricts and regions are mostly exhausted according to the prevailing conditions, but in the field of the non-metallic raw materials vast possibilities appear in last decades. Exploitation of non-metallics exceeded in 1950 the bulk of ore exploitation of ores by 20%, but in 1980 it will attain about 60 to 65%, due to the scientific-technical revolution in all industrial branches.

Many new types of raw materials have been applied on wide scale. Various combinations of non-metallic raw materials with other artificial products or semi-products /e.g. plastic compounds, used materials of different industrial origin a.o./ have achieved large aplication in the industry, agriculture and private life too.

The chief methods of geological prospecting work /for non-metallics/ have already been verified. The techniques and instrumentation used to detect the properties of the deposits by remote sensing are continuously being refined.

New genetic models of deposits are based on laboratory investigation of phase equilibria, on experiments focused on the interaction of solid mineral associations, solutions and gases as well as on the interaction of inorganiccomponents and organic substances. Study has been made of the kinetics of geological processes which result in the formation of nonmetallic mineral associations, and models of paleogeological and paleoclimatic reconstruction have been elaborated. The evolution of computing techniques solved the problems related to the processing of a large number of data. However, specialists have so far failed to bridge the gap between geology and technology, to tackle in time the problems resulting from rapid development, and to cope with the requirements of the construction, power and engineering industries as well as with the change of production processes and with transport problems. There is no coordination and there are no interdisciplinary bonds in the broadening of geological knowledge and the specialization of production.

The world exploitation of nonmetallic minerals totals about 13 billion tons and the world exploitation of ores about 0.6 billion tons. The exploitation of raw materials for the building industry has set maximum records and is about 9 times superior to that of other nonmetallic raw materials. The enormous consumation of foodstuffs due to the population explosion and the increase of living standards exert constant pressure on the exploitation of mineral fertilizers, whose production value is mounting. The uneven distribution of phosphates and potassium salts in the world and their increasing demand in agriculture spurs the search for new types of raw materials and their processing. This is a common trend for all nonmetallic raw materials which depend far more than ever before on processing or the progress of technology. Thus e.g. miniaturization in electronics diminishes the perspective demand for the exploitation of tabular mica or, in the sphere of energy and steel industries, enhances enormously the requirements for the purity of some nonmetallic raw materials such as e.g. magnesites. In thirty cases of nonmetallic raw materials forecasts concur that the consumption of these materials is to increase two to five times compared to the current state.

This will undoubtedly lead to the transfer of exploitation interests from the continents to the oceans. /For the time being only magnesium, bromine, salts and deuterium oxide - heavy water - are extracted from the seas in addition to fresh water./ Nevertheless, the demands for conservation both on the continents and in the oceans will increasingly impose limitations on the insatiable quest for raw materials. Projects using nuclear energy for the cheap exploitation of raw materials on the continents, or plans to utilize the oceans as sources of raw materials have already been drastically curtailed by pollution obstacles. Consequently, the increase in exploitation in countries with a strictly planned exploitation regime or with underdeveloped industry and sparse habitation will long remain in the centre of geological interest. This is also well visible from curves of total production indicating that the growth index of the world's production of raw materials is increasing most rapidly in the socialist countries, where production is being organized on a state-wide scale. Ultimately it is environmental problem that will presumably unite ore and nonmetallic geologists in the search for raw materials producing ores and nonmetallic materials at the same time and utilizing waste for further production for recultivation unless the waste itself becomes a source of necessary materials.

The wide diversity of use of nonmetallic raw materials leads to a number of different classifications compiled according to various viewpoints. The simplest way of classification of nonmetallic raw materials is the following subdivision:

- raw materials used /after dressing/ as minerals /e.g. asbestos, talc, diamonds, and others/, or as rocks /diatomite, bentonite, phosphates, clays, etc./;
- raw materials employed in the production of nonmetallic elements /e.g. pyrite, fluorspar, apatite/, or of their simple compounds /borates, nitrates/;
- raw materials with nonmetallic appearance which are source of both metals and their compounds /beryl, magnesite, bauxite, Al-laterite, the last as a source of Al_2O_3 and refractory materials/;
- raw materials used in building /e.g. granite, marble, gravel, sand a.o./.

Some of the nonmetallic raw materials can be employed in several ways, e.g. chromite, from which both the element chromium and refractory materials are produced, and which can also be used as a chemical raw material in chemical industry. Similarly, bauxite primarily yields aluminium, but its other use is as refractory and abrasive material.

With increasing ability of man to employ natural resources, different minerals and rocks are considered mineral raw materials at different evolution stages. Thus e.g. at the beginning of the 20th century some 60 types of mineral raw materials were employed, whereas more than 200 types of various natural raw materials are currently being mined throughout the world, including seas and oceans and their bottom.

Prospecting and exploration for deposits of non-metallic raw materials is mostly based on general experiences of all branches of geosciences as practical conclusions on stratigraphy, the petrography of sedimentary, igneous and metamorphic rocks, tectonics, structural geology and the facies concept, geochemistry, geomorphology, hydrogeology, geophysics, history and mining geology.

Stratigraphical criteria are important in the search for sedimentary deposits and hypogene deposits that are associated with beds of lithologically favourable sediments /see below/.

Throughout the world, deposits of coal, sedimentary copper ore, uranium, lead and zinc, pyrite, sulphur, phosphates and bauxite, sedimentary iron and manganese ores, placers, clays, carbonates, vanadium and salts are restricted to several well defined stratigraphical horizons.

Lithological criteria - The composition of sedimentary ores is always closely connected genetically with the lithology of the wall rocks. The potential occurrence of an ore can be inferred from the lithological character of the surrounding sediments.

Some sedimentary deposits are invariably over- or underlain by particular rocks. Thus, the oolitic manganese ores of the Chiaturi type are underlain by siliceous sediments such as marly sandstones, spongolites, or jaspers with radiolarians. In addition to positive criteria-based on a knowledge of the environment of their origin- there are also negative prospecting criteria, such as thick sandstone complexes for coal deposits. Evidence of changing denudation trends /e.g. polymictic sandstones/ implies that a coal seam, if it ever existed, has been destroyed by erosion.

The lithology of rocks is of special importance for deposits of the placer type. In depressions of river beds, produced by the selective erosion of lithologically variable rocks, the natural washing of the alluvium results in the accumulation of heavy minerals and the formation of placers.

Structural criteria - The structure of the earth´s crust is often a controlling factor in the formation of ore deposits. Numerous types of metallic and non-metallic deposits of endogenic origin, for example, are confined to folded areas or more precisely, to the magmatic bodies intruded into them. These deposits usually originate in the last orogenic cycle within an area. In contrast, coal, oil, carbonates, manganese, bauxite and some phosphate deposits are also found in transitional areas characterized by slight folding and cupolas.

Geomorphological criteria are particularly important in the prospecting for placer deposits, which should be carried out first in the areas that have been poorly investigated geologically, for example, in developing countries.

Indirect geomorphological criteria such as tectonic steps, hogbacks and cuestas, reveal the tectonic structure of the area. Direct criteria concern the surface features of the deposit, which can be either positive or negative.

Deposits can be related to the topographic evolution of the area /exogenic deposits/ or formed irrespective of it /endogenic deposits/. The former can be related to the recent topography /placers, residual deposits, some deposits of bauxite, clay, sand and gravel/ or to fossil relief /marine sedimentary Fe and Mn deposits, deposits of bauxite, phosphorite or carbonate rocks/; prospecting for the latter utilizes palaeogeographic criteria.

Palaeogeographical criteria - Mineral deposits related to ancient relief forms developed in peneplains /residual deposits of the weathering crust/, in lakes /often with through-drainage/, swamps and rivers /platform coal dposits with a small number of very thick seams, slightly affected tectonically/, on coastal plains /U and Cu-bearing sandstones/, in coastal lagoons and swamps /transitional type of coal deposits/, laggons /deposits of salt, sulphur, sedimentary copper and uranium ore, bituminous shales/, in the littoral of shallow seas /phosphates, sedimentary iron and manganese ores/ and neat deltas /intensively folded and metamorphosed geosynclinal coal deposits with a large number of extensive but thin seams, form the late stage of geosynclinal evolution/

The palaeogeographical factors that are significant in prospecting for mineral resources can be placed in several categories, each of which demands special attention. These are: 1. the relief of the source and accumulation areas, 2. the climate, 3. the ancient drainage pattern, 4. the form of the shoreline, 5. the direction of currents in the accumulation area /in the river, sea or lake/, and 6. the presence of volcanic centres. All these factors are affected by tectonism.

Palaeoclimatic criteria are particularly important in prospecting for deposits related to weathering crusts. The residues of some rocks are enriched through weathering with poorly migrating elements to form economically valuable accumulations, such as Ni-hydrosilicates on serpentinites, Al-rich laterites on rocks poor in Fe, kaolins on felospathic rocks, Mn-oxides on Mn-rich rocks /e.g. gondites/ and gossans with Au, Pb and Fe on the corresponding primary deposits.

Geological prospecting and exploration methods became a routine complex of geological procedures involved according to the stage of knowledge in each locality or area specific due to different geological conditions, different economic position of expected deposit and with respect to the previously executed geological work.

In socialist countries in frames of CMEA there have benn introduced quite exact - quantitative and qualitative methods of evaluation for individual types of raw materials. Calculation of geological reserves, which is the final point of geological exploration, is based upon the degree of discovery and investigati of the explored deposit or type of mineral raw material. Following classification is being applied, which is eminent not only for economic geology, but also for implication of special prospecting methods, like geophysical and geochemical ones:

Stage of geological work	Category of reserves	English equivalent of categories	Scale
1.Prospecting	D_2	geol. probable	regional 1:100 000 to
		geol. expected	1:50 000 to 1:20 000
	D_1	geol. possible	
	C_2	geol. estimated	1:20 000 to 1:5 000
2.Exploration	C_1	industrial possible	detailed 1:5 000 to 1:1 000
	B	industrial proved	1:1 000
3.Mining exploration	A	for mining purposes	industrial 1:1 000 to 1:500 /in special cases also 1:200/

Mathematical classification using the defined ranges of geological work with specified accuracy from the beginning till to the calculation of reserves seems to be most efficient in most cases, but in many countries the tradition is too strong and the influence of big mining companies is mostly ruling the main prospecting and exploration projects - neglecting the basic geological laws of consequency for the executed methods. For this reason we recall to the existing systems, as described in the book of Kužvart-Böhmer /1978/:

"Prospecting and exploration of mineral deposits forms together with economic geology, hydrogeology and engineering geology part of applied geology. Ore prospecting and exploration are undertaken in a logical time sequence. The target of prospecting is to find useful mineral deposits and appraise their suitability for further exploration.

Prospecting takes place in four succesive stages: general, preliminary, detailed and prospecting-exploratory. General prospecting is conducted simultaneously or subsequently after geological mapping on a 1:1 000 000 or 1:500 000 scale. Broad prospecting criteria and indications of mineralisation are determined.

Preliminary prospecting is based on geological maps on scales of 1:200 000 or 1:100 000. At this stage the stratigraphy, tectonics, petrography should be studied so that prospecting criteria are determined precisely and indications of mineralization located accurately. Map showing the distribution of mineral resources is being compiled. Detailed prospecting is based on a geological map of a scale 1:50 000 or 1:25 000 and should enable evaluation of indications of mineralisation and a decision as to whether the occurrence is of mineralogical interest only or a prospecting-exploratory stage is justified. For the construction of the geological map at least one outcrop or man made exposure per 1 cm^2 of the map is required. If neccessary a few deep drill holes are sunk.

In following table examples of time and cost of prospecting and exploration stages are given:

Stage	Result	Cost as a percentage of total expenditure	Duration
Prospecting /general, preliminary, detailed/	discovery of mineral concentration, differentiation of mineral occurrences and deposits, calculation of hypothetical reserves /during detailed prospecting/	3	1-20 years
Prospecting-exploratory stage	differentiation of economic and subeconomic deposits, calculation of inferred /C_2/ reserves	3	3 months to 3 years
Preliminary exploration /often associated with the precious stage/	calculation of indicated /C1/ reserves	6	3 months to 3 years
Detailed exploration /often associated with preparation for mining/	calculation of indicated /B/ reserves	7	2-5 years
Construction of mine and dressing plant during the preparation for exploitation	calculation of measured /A/ reserves	80	2-5 years
Beginning of operation	calculation of measu /A/ reserves	1	1-6 months

It is neccessary to point out, that neglect of the principle of multistage exploration may led to substantial financial losses in some cases.

In the prospecting-exploratory stage detailed geological mapping, geophysical and geochemical methods and structural studies are employed; outcrops and man-made exposures are described thoroughly. The main purpose of the prospecting-exploratory stage is economic evaluation of the mineral deposit.

The prospecting-exploratory stage is the first to provide detailed data on the deposits. Geophysical and structural-geological prospecting works are conducted on the basis of geological maps of scales of 1:10 000 and 1:5 000 /of 1:25 000 or 1:50 000 for sedimentary deposits/ and outcrops of deposits are assessed.

The prospecting-exploratory stage lies on the boundary between prospecting and exploitation stages; for example a drill hole which encounters a concealed deposit is a "prospecting hole" but the following drill holes will be "exploratory".

Structural research and mapping during the prospecting-exploratory stage should be related not only to the location and course of major faults and fault zones, but also to the joint and fracture systems, bedding, schistosity and lineations. A detailed, statistically precise record of the strike and dip of joints and fractures is presented by a rose diagram or a contour /point/ diagram.

In detailed geological mapping all outcrops and exposures of rocks and mineral deposits are documented. Great attention is paid to secondary aureoles of ore elements in the overburden, which is also examined with a view to future exploration and the construction of a mining and dressing plant /bearing capacity, suitability of rocks for backfilling or as a raw material for brick making/.

The results of the prospecting-exploratory stage should decide wether the importance of the deposit studied justifies preliminary exploration or whether the deposit is subeconomic.

A slightly different classification of exploration of mineral deposits was resently presented by J.B.Rivington /1978/:

Method:		Stage:
1/ Regional mineral investory	:	Project appraisal stage
2/ Detailed exploration	:	Pre-feasibility stage
3/ Economic evaluation	:	Feasibility stage

The exploration of mineral deposits is conducted as mentioned above in two stages, preliminary and detailed. Preliminary exploration is carried out on those deposits which, according to prospecting results, proved to be most promissing. The most important task of preliminary exploration is to assess the economic value of the deposit with reasonable accuracy. Such exploration must also provide sufficient information so that an adequate method of detailed exploration may be selected. On the basis of a technicaleconomic evaluation the decision is taken on whether detailed exploration is advisable or not. If a deposit proves to be workable but its exploitation is postponed for 10-15 years, it is considered as a state reserve. Detailed exploration is started on economically important deposits which are intended for immediate development as part of a programme for exploiting mineral resources and in agreement with local industry. The aim is to appraise the reserves and assemble all data necessary for the construction of a mining plant. Apart from certain details, the working methods for the two exploration stages are practically the same, but as the stages differ in their objectives, the degree of preciseness to which the deposit is explored also differs.

Classical prospecting and exploration methods used in economic geology are frequently combined with methods, which determine the physical and chemical properties of mineral raw materials in the deposit and around the deposit which is subject to the evaluation. Mainly the geophysical and geochemical methods are introduced during the different stages of prospecting and exploration as mentioned above:

Geophysical methods can be used with success in the exploration of numerous nonmetallic deposits such as building and cement raw materials /sand, gravel sand, limestone, loam, building stone/, ceramic raw materials /kaolin, cla graphite, fluorite, pegmatite, salt etc. Geophysical methods are also employed in the prospecting for nonmetallic deposits or structures as well as in the tackling of structural-technical problems, study of deposition conditions, of the quality of individual parts of the deposit etc.

Low cost, speed and the feasibility to be used for the mapping of larger areas are the chief advantages of geophysical methods which can be applied in the prospecting i.e. preliminary stage, as well as in the exploration of the deposit.

A complex of methods - geoelectrics, seismics and magnetometry - are commonly in use. Gravimetry and radiometry are applied under specific conditions. Geophysical measurement in boreholes /logging/ is employed in exploration and during exploitation /mining exploration/.

The success of the application of geophysical methods depends in the first place on physico-geological setting of the area. The appraisal of the contribution of geophysical measurement from the viewpoint of information needed and financial costs is also necessary. Close cooperation between the geophysicist and the geologist is inevitable in the tackling of the problems cited, in the choice of the method of measurement and geological interpretation.

Geochemical prospecting and exploration methods are based on the feature that mineral deposits constitute an "anomalous" concentration of one or more elements in the earth's crust, thus contrasting with the surrounding "background" country rock. During the process of surface and near surface weathering these anomalous concentrations, namely of metals become incorporated in the weathering products and through the natural processes of chemical and mechanical breakdown spread outwards from deposit giving a "dispersion halo" which provides a considerably larger exploration target, than the ore deposit itself. The "dispersion haloes" may be classified as follows:

a/ Primary dispersion haloes /aureoles/ i.e. dispersions of elements in the unweathered rocks surrounding the deposit, b/ Secondary dispersion haloes /aureoles/ which represent redistributed elements of primary aureoles and mineral deposits under the influence of weathering and oxidation processes.

Geochemical methods useful in tropical and subtropical countries differ from those used in moderate climatic zones. The most important method in arid and semiarid regions with outcrops of primary rocks is the investigation of primary aureoles accompanied by geological mapping, by the study of heavy minerals in weathered rocks and trace elements in some primary minerals /e.g. biotite/ and by application of geophysical methods. If the primary rocks are covered by a weathering crust, metallometric curvey of soil samples, biogeochemical and hydrogeochemical methods are carried out. Areas with thick eolian cover are not suitable for geochemical prospecting methods. In humid tropical regions with deep weathering and lateritic hardpan on the surface, only the biogeochemical method can be used. Where the hardpan is missing metallometric soil sampling as well as hydrogeochemical prospecting is useful. Sampling of stream sediments and heavy minerals in river beds can be use[illegible] mid tropics with or without lateritic hardpancover.

Orientation surveys - should be conducted in every new area. The objective of such a study is to determine namely: a/ the type of geochemical dispersion, b/ the best sampling medium, c/ the optimal sampling interval, d/ the size fraction to be analysed, e/ the element or group of elements which should be analysed, f/ the upper limit of background value etc. in the following table are given examples of sampling network dimensions.

Metailometric sampling			Sampling of stream sediments		
Scale	spacing profiles /km/	spacing of points in lines /m/	spacing of samples /m/	number of samples per 1 km of the drainage pattern	number of samples per km2
1:1 000 000	12-8	100			
1:500 00	6-4	100			
1:200 00	2	100-50	800	1.25	1.7-2.1
1:100 000	1	100-50	400	2.5	4.0-5.0
1:50 000	0,5	50-40	200	5	8.5-14.0
1:25 000	250-200	40-20	100	10	18.0-32.0
1:10 000	100	20-10			
1:5 000	50	20-10			

Geochemical prospecting methods are most succesfully used for the prospecting of metallic raw materials, petrol and gas. Geochemical methods may be also applied with success for the search of non-metallic raw-materials e.g. deposits of potash, nitrates, fluorite, baryte, sulphur, phosphates, pegmatitic deposits of feldspar, mica and beryle, magnesite, talc, asbestos etc.

In prospecting for concealed deposits three problems hould be studied: 1. the theoretical possibility of the existence of concealed deposit, 2. surface indications of concealed deposits and 3. prospecting methods.

Theoretically, potential reserves of concealed deposits are larger than those of deposits cropping out on the surface. According to calculations, only 20 per cent of all deposits occuring to a depth of 1.000 m crop out on the earth's surface. The importance of the remaining 80 per cent of deposits which are hidden at depth will steadily increase, but precise methods for their exploration have not been developed so far.

The existence of concealed deposits is governed 1. by the vertical range of the ore complex, 2. by the vertical dimensions of ore bodies and their dip, 3. by the depth of erosion of the ore complex, 4. by the character of ore-bearing structures, and 5. by the composition of the wall rock.

Concealed deposits are divided into covered, deep-seated /unexposed/ and buried. With covered deposits the thickness of the younger formation is decisive for the application of geophysical prospecting methods and subsequent drilling at the sites of established anomalies.

Final stage of most of the prospecting and exploration projects for mineral raw materials should be expressed by the calculation of discovered or proved geological reserves of specified raw material.

Calculation of mineral reserves comprises not only calculation of the amount of useful minerals and determination of the quality and economic importance of the deposit, but also drawing up of a final report summarizing all information obtained in the individual exploration stages.

The report contains the following chief items of informations:

1. The amount of industrial raw materials and distribution of the individual kinds in the deposit,
2. the quality of the mineral materials,
3. geological conditions that are decisive for selecting the mode of opening the deposit and the mining method,
4. reliability of the calculation of reserves and the degree of geological assurance for a confident estimation of the industrial value of the deposit.

The calculation of geological reserves of non-metallic mineral raw materials needs in all cases establishing of so called "technical geological conditions" approved by Governmental Authorities for each stage of prospecting and exploration /geol. categories "A" till "D"/ as mentioned above. Practically for each deposit which is going to be mined "specific technical geological conditions" are issued. In connection with an exact definition of these "conditions" the technological view is being considered as one of most aspects.

This lecture does not include the description of necessary technological tests, which are executed during the prospecting and exploration stages, as following lectures will describe all these procedures and stages more in detail.

Main aspects ruling the prospecting and exploration together with industrial evaluation of non-metallic mineral raw materials, especially in developing countries, can be summarized in a table on the next page.

Explanation:

This lecture is based on geological materials collected for the "INTERNAL SCRIPT FOR SCIENTIFIC SEMINAR UNESCO GEO NONMETALLIC 1979", which has been organized by the Syrian Government, UNDP and UNESCO at Damascus /Syria/ during September till November 1979 with help of Czechoslovak specialists. The lectures were edited in English by ÚÚG Praha for UNESCO participants only.

Praha, 30.11.1979

Significance of non-metallic material for developing countries

Factors influencing significance										Non-metallic material
1	2	3	4	5	6	7	8	9	10	
+	+	-	-	-	-	+	0	-	+	Asbestos /chrysotile/
-	-	-	-	-	0	0	-	-	-	Bentonite and montmorillonite clay
-	-	-	-	0	-	0	0	-	0	Grinding and polishing
-	-	-	-	-	0	-	-	-	-	Brick
-	-	-	-	0	0	0	-	+	-	Decorative stone
-	+	-	-	0	-	+	0	-	+	Diamond /gem, industrial/
-	-	-	-	0	0	-	-	0	-	Dolomite
-	0	-	-	0	0	+	-	-	+	Jewel
+	-	-	-	-	-	+	-	+	0	Potassium salt
0	0	-	-	-	-	+	0	+	0	Fluorite
-	-	-	-	+	-	+	-	+	0	Phosphorite /phosphate/
0	0	-	-	-	-	+	0	0	0	Graphite
-	-	-	-	0	+	-	-	+	-	Clay and claystone /refractory/
-	-	0	-	0	0	0	0	+	0	Kaolin
0	-	-	-	-	0	0	0	-	0	Diatomaceous earth
-	-	-	-	-	0	+	+	-	+	Quartz and crystalline quartz
-	-	+	0	0	-	+	-	+	0	Laterite and bauxite
-	-	-	-	+	-	0	-	0	0	Talc
-	-	-	-	-	-	0	-	-	0	Mineral pigment
0	-	-	-	0	-	+	-	-	+	Muscovite /mica scales/
-	-	-	-	-	0	+	-	-	-	Pumice
-	-	-	-	-	0	+	0	0	0	Perlite
-	-	+	+	-	-	0	+	+	-	Cast basalt
0	-	0	-	-	0	0	0	0	-	Gypsum
-	-	-	-	-	-	0	-	0	0	Sulfur
-	-	-	-	-	0	0	0	0	0	Glass and foundry sand
-	-	-	-	-	+	-	-	+	-	Building stone and sand and gravel
-	-	0	-	-	0	0	-	0	0	Salt
-	-	-	-	0	-	0	+	-	0	Boron bearing
-	-	0	-	-	+	-	-	-	-	Limestone and other cement material
+	-	-	-	-	-	+	+	-	+	Wollastonite
-	-	-	-	-	0	0	0	0	-	Feldspar and feldspathic material

Explanation

Factors influencing significance

1 - insufficient activity shown in prospecting for and exploitation of raw material
2 - geological reserves insufficient to meet the world consumption in next forty years
3 - energetic problems in treatment
4 - problems encountered in improving technological treatment
5 - problems connected with exploitation
6 - material suitable for developing domestic industry /DC in general/
7 - material suitable for export /DC in general/
8 - problems associated with the ensurance and training of geological staff, incl. laboratory as well as technological treatment /for DC in general/
9 - transport and limited exploitation /DC in general/
10 - price of material, according to world market

Classification of factors

+ significant
O less significant
- insignificant