BIOTECHNOLOGIES IN MINING

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Biotechnologies in mining

- Bioprospecting of microbial catalysts for various processes
- Biobeneficiation of ores through bioflotation and leaching of unwanted elements
- Pre-treatment of refractory gold-ores through bio-oxidation
- Bioleaching of metals from sulfide and oxide ores through oxidative and reductive processes
- Bioleaching and electrochemical leaching of metals from waste materials
- Biotechnical recovery of metal values from leach liquors
- Biodegradation of organic impurities
- Biotechnical removal inorganic impurities (e.g. metals, sulfate, acidity) from hydrometallurgical process waters
- Acid mine drainage treatment
- Microbially induced problems such as biofouling and bioclogging of water production bores and microbially influenced corrosion of infrastructure.

- https://www.csiro.au/en/work-with-us/industries/mining-resources/mining/mining-biotechnology

Bioprospecting of microbial catalysts for various processes

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Iron and sulfur oxidation by bacteria

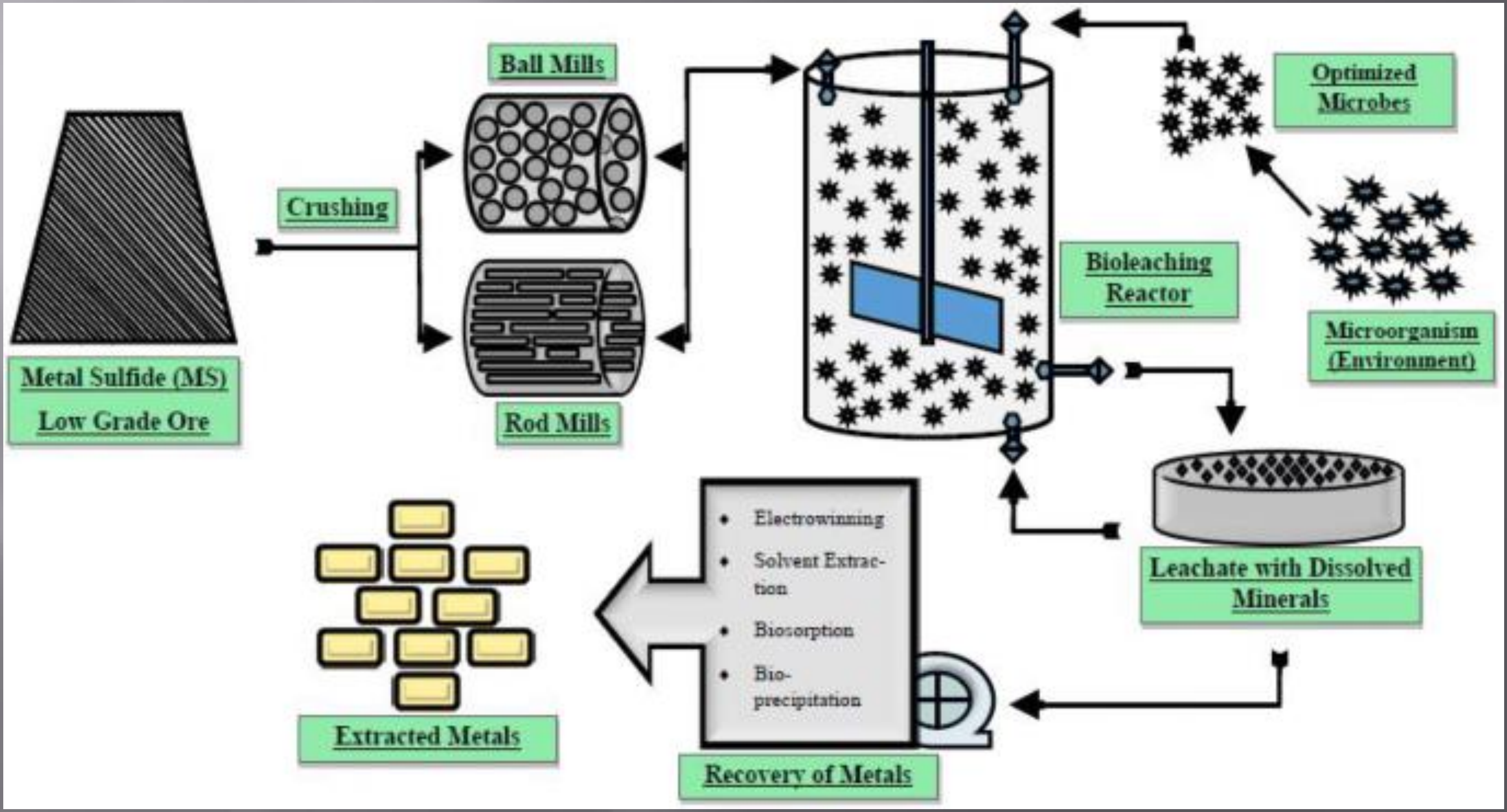
- direct and indirect mechanism by oxidizing Fe2+ to Fe3+

$$2Fe^{2+} + 0.5O_2 + 2H^+ \xrightarrow{\text{bacteria}} 2Fe^{3+} + H_2O$$

$$MS + 2Fe^{3+} \xrightarrow{\text{bacteria}} M^{2+} + S^o + 2Fe^{2+}$$

Metals Extraction from Sulfide Ores with Microorganisms: The Bioleaching Technology and Recent Developments

Wasim Sajjad, Guodong Zheng, Ghufranud Din, Xiangxian Ma, Muhammad Rafiq & Wang Xu



Microbial and culture dumping

- Microbes are dumped on the heap contents for the extraction of valuable elements.

Direct Bio Leaching:

- Enzymes, used for oxidation
- Electrons, transported through cell membrane

Indirect Bio Leaching:

- Energy generated by Bacteria

govt .science college ,tumkur,(govt.estab)

Bioleaching microorganisms

The most important mineral-decomposing microorganisms:

- – Fe- and S- oxidizing chemolithotrophs:
- Obtain energy from inorganic chemicals , use CO2 as carbon source
- H-, S-, Fe- reducing Bacteria and Archaea

The most important mineral-leaching microorganisms:

- Use Fe- and S- compounds as electron donors and fix CO2
- Produce sulfuric acid (acidophiles)

Microbes involve in Biomining:

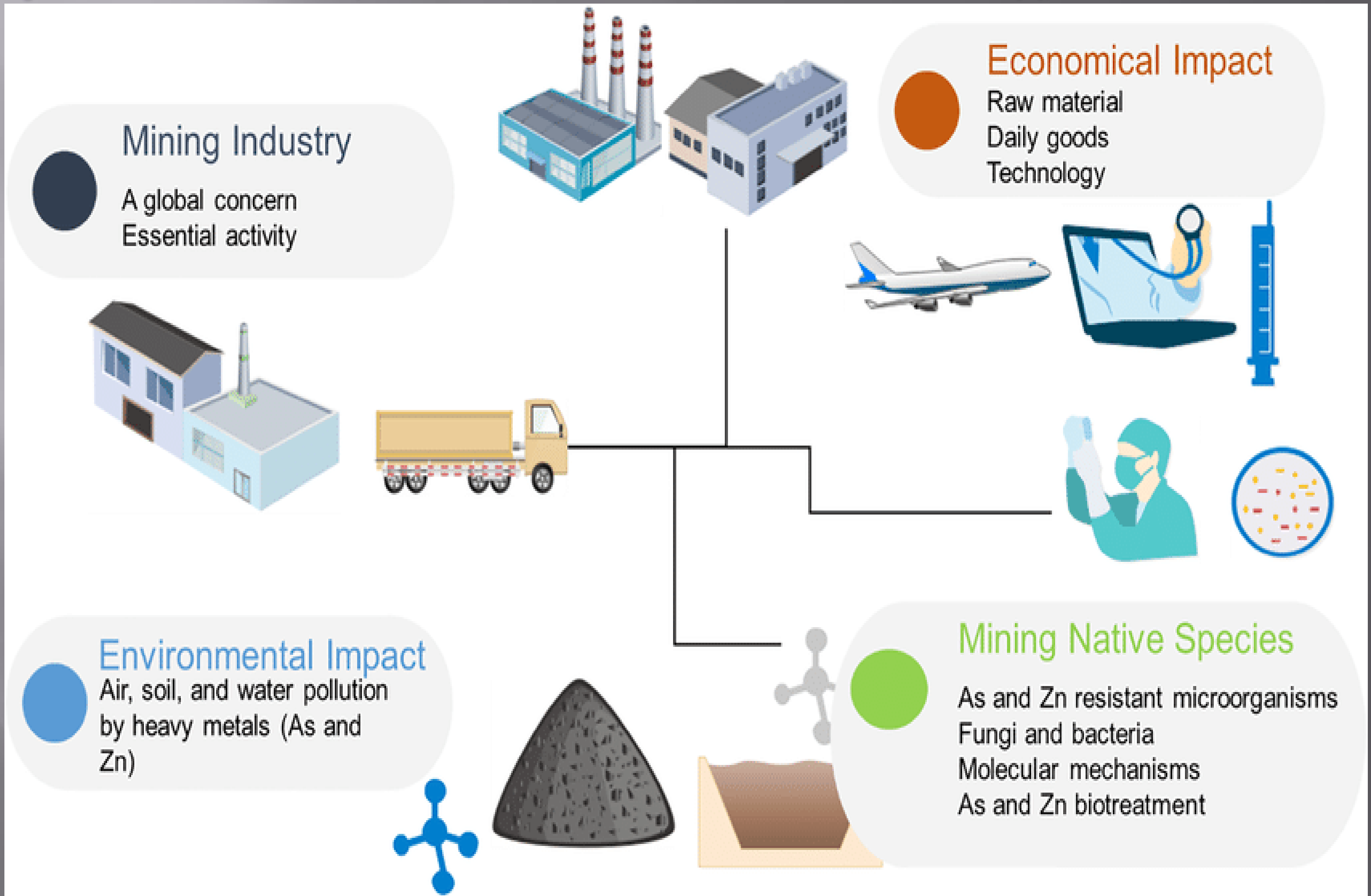
- Iron and sulfur-oxidizing microbes are used to release occluded copper, gold and uranium from mineral sulphides.
- Some microbes produce acids called **bioacids**.
- *Acidithiobacillus* or *leptospirillum ferrooxidans* produce acids.
- These acids oxidize or reduce the metals or other elements into solublize form.
- *Pyrococcus furiosus* and *Pyrobaculum islandicum* are iron and sulfur oxidizer.
- *Pyrococcus* **species** were shown to reduce gold chloride to insoluble gold.

Some Metal-leaching microorganisms

Organism	Type	Metabolism	pH optimum	Temperature range (℃)
T. prosperus		Halotolerant/ Fe/acid	2.5	30
Leptospirillum	ferrooxidans	Fe only	2.5-3.0	30
Sulfobacillus	acidophilus	Fe/acid	- •-	50
S. thermosulfi-	dooxidans	Fe/acid	—	50
L. thermoferro-	oxidans	Fe	2.5-3.0	40-50
Acidianus	brierleyi	Acid	1.5-3.0	45-75
A. infernus		Acid	1.5-3.0	45-75
A. ambivalens		Acid	1.5-3.0	45-75
Sulfurococcus	yellowstonii	Fe/acid	-	60-75
T. thiooxidans		Acid		25-40
T. acidophilus		Acid	3.0	25-30
T. caldus		Acid		40-60
Sulfolobus solfataricus	Archaean	Fe/acid	-	55-85
S. rivotincti	Archaean	Fe/acid	2.0	69
S. yellowstonii	Archaean	Fe/acid	-	55-85

Biotechnological Potential of As- and Zn-Resistant Autochthonous Microorganisms from Mining Process

Edgar Ricardo Meléndez-Sánchez, María Adriana Martínez-Prado, , iola Marina Nunez-Ramirez[...], Luis Medina-Torres



Advantages of biooxidations

- After biooxidation 95% of the gold (and other metals, copper etc.) can be recovered - in opposite to traditionally 30-50%
- Relatevely little of the ore needs to be decomposed to allow gold recovery
- Advantage of natural weakness in structure
- Costs in 2-3 times less
- More economical and environmental friendly

Types of plant bioindicators

- indigenous organisms → “passive” biomonitors
  → spatial distribution of bioavailable pollutants
  (e.g. heavy metal resistant / accumulating plants)

Festuca ovina *Calluna vulgaris* (**excluder**)

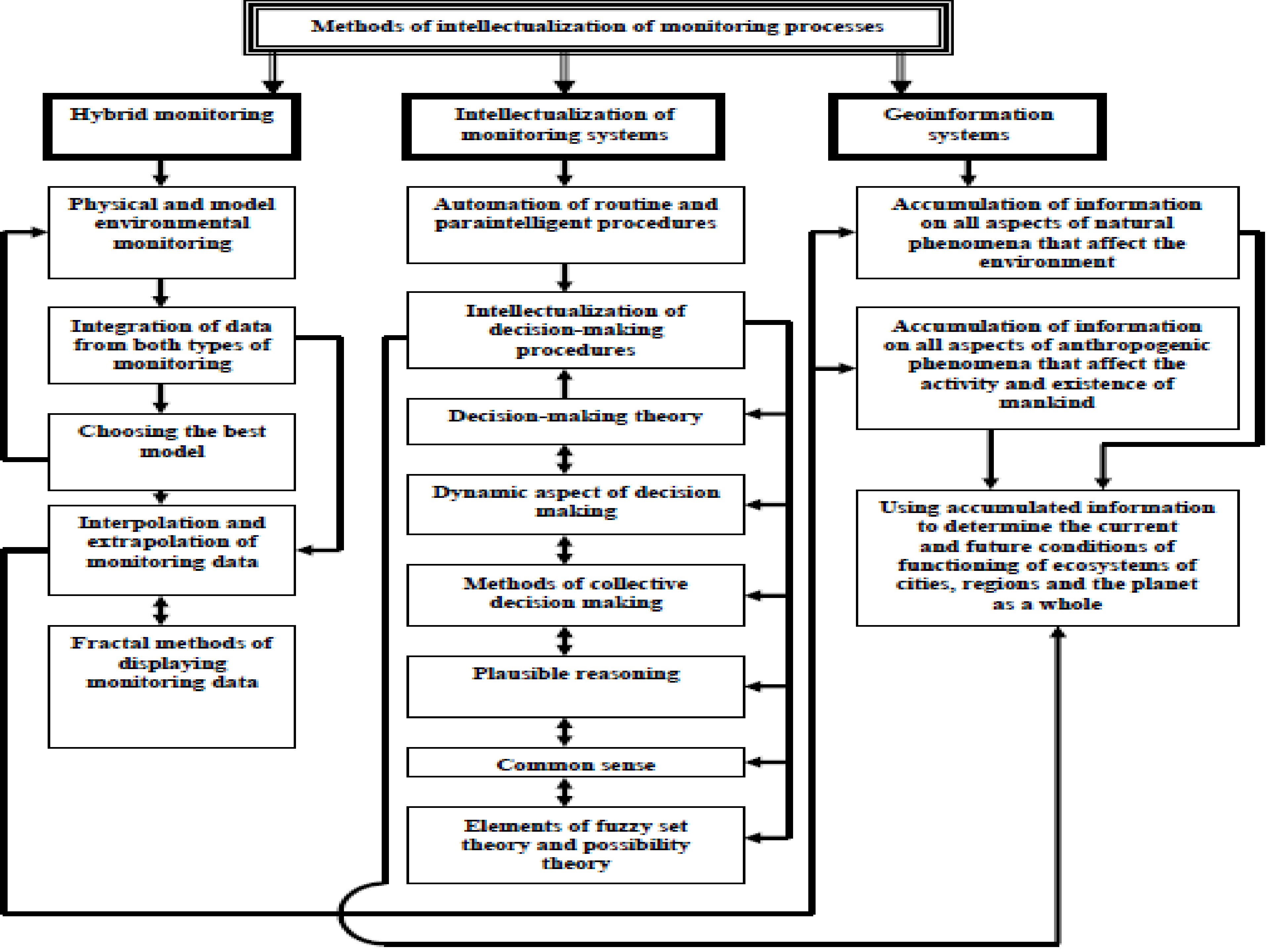
Silene vulgaris

Minuartia verna
(accumulators)

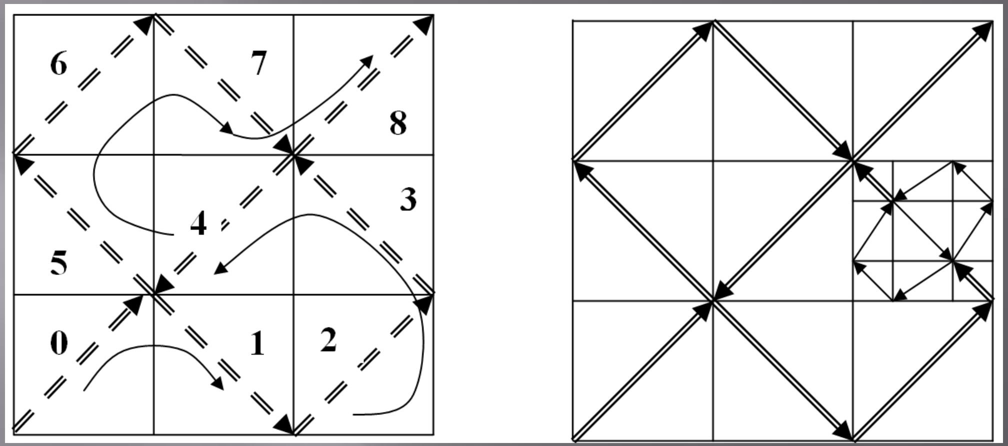
Soil enzymes as biomonitors for soil pollution

Effect of trace metals on soil enzyme activities

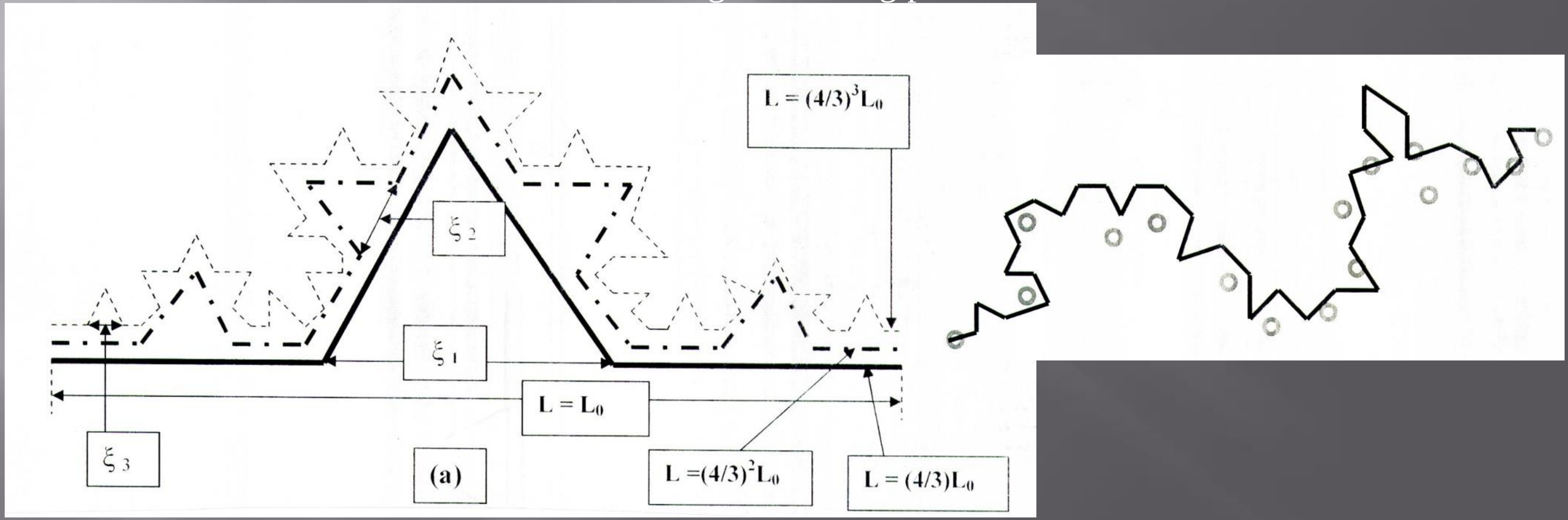
	Aue (floodplain of Mulde river)		Lichtloch	Davidschacht	Rauchblöße
As (mg/kg):	0.1	0.05	5.6	n.d.	4.1
Pb (mg/kg):	91	36.8	36.8	340	1800
Cd (mg/kg):	13.8	6.8	2.3	5.7	2.6
Zn (mg/kg) :	662	270	90	427	38


Methods of intellectualization of monitoring processes
Hybrid monitoring
Intellectualization of monitoring systems
Geoinformation systems
Physical and model environmental monitoring
Integration of data from both types of monitoring
Choosing the best model
Interpolation and extrapolation of monitoring data
Fractal methods of displaying monitoring data
Automation of routine and paraintelligent procedures
Intellectualization of decision-making procedures
Decision-making theory
Dynamic aspect of decision making
Methods of collective decision making
Plausible reasoning
Common sense
Elements of fuzzy set theory and possibility theory
Accumulation of information on all aspects of natural phenomena that affect the environment
Accumulation of information on all aspects of anthropogenic phenomena that affect the activity and existence of mankind
Using accumulated information to determine the current and future conditions of functioning of ecosystems of cities, regions and the planet as a whole

Determination of minerals area

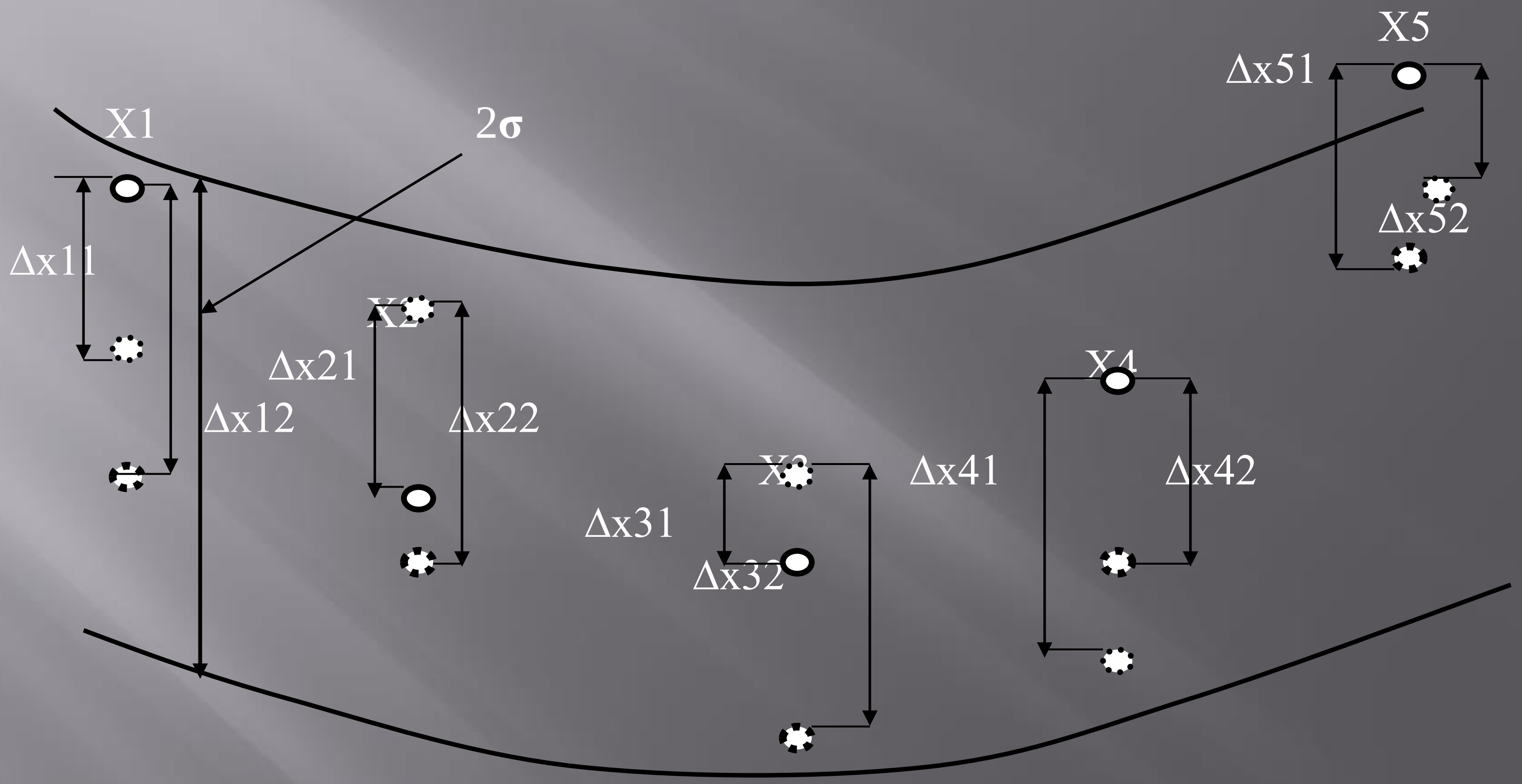


Scheme for determining monitoring points on the Peano curve



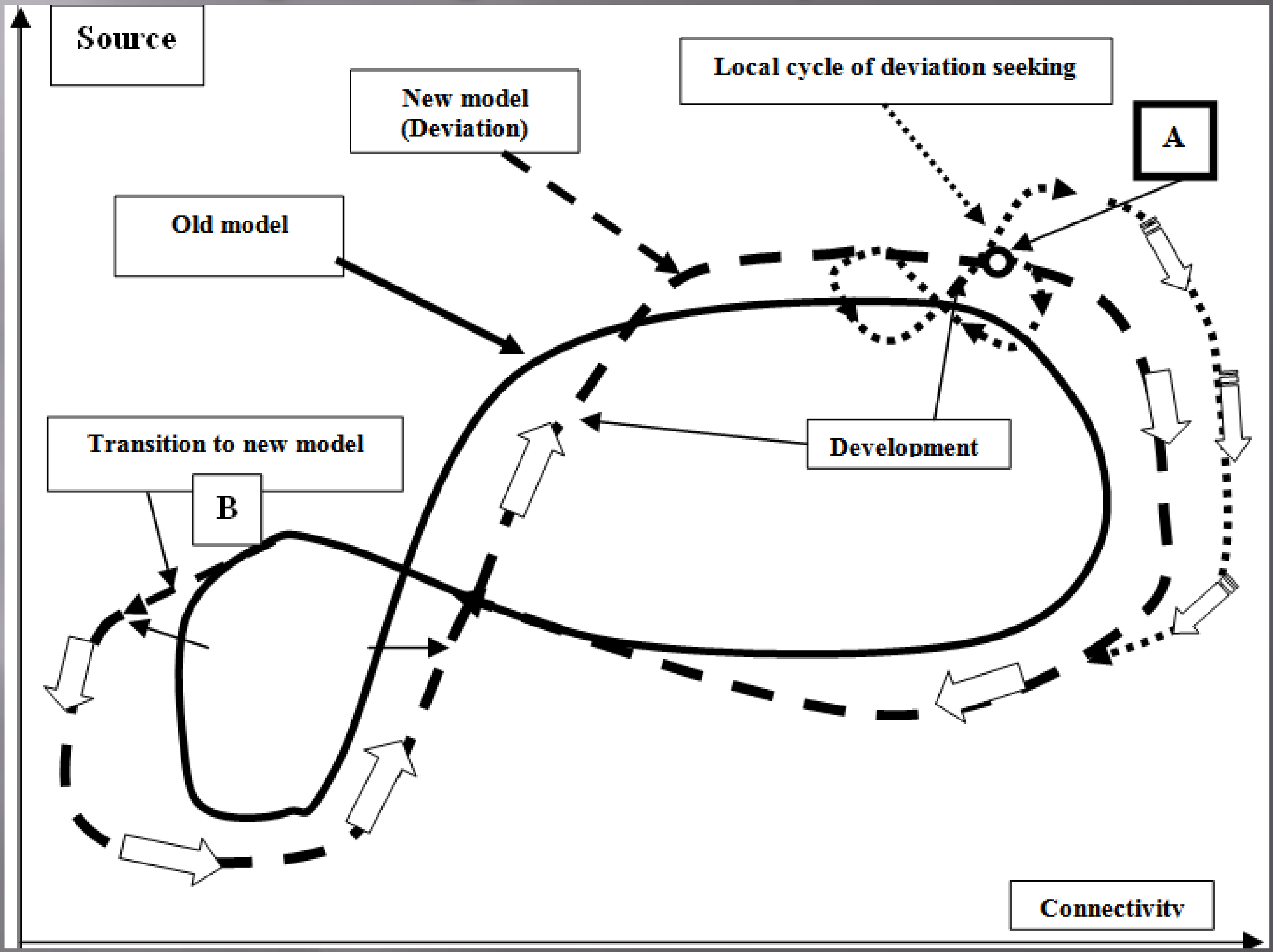
The scheme of a contour of pollution on a Koch curve

Graphic interpretation of the method "Comparative analysis of data of the nearest neighbors"



IF ([МСТАБ] AND [SIGNΔSTi±jEQ]), THEN [СПТ]

Functioning of the complex geological ecosystem



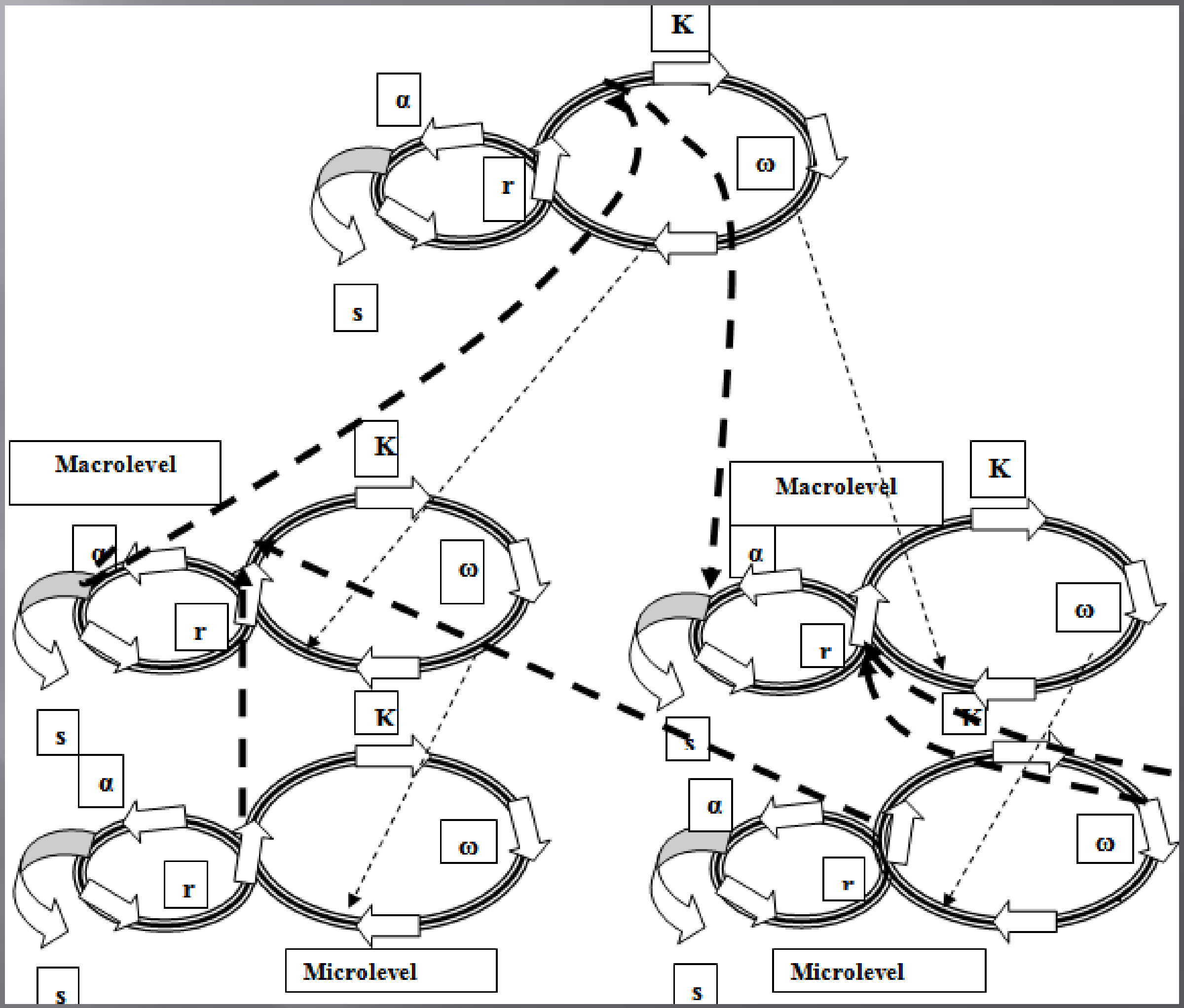
r – development, *K* – conservation, *ω* – crisis, *a* – reorganization, *s* – restructuring

Heuristics to ensure the adaptation processes in the system

$$IF\ ([RI > 0]\ AND\ [CI > 0]),\ THEN\ (D);$$
$$IF\ ([RI \sim 0]\ AND\ [CI > 0]),\ THEN\ (CS);$$
$$IF\ ([RI < 0]\ AND\ [CI < 0]),\ THEN\ (CR);$$
$$IF\ ([RI > 0]\ AND\ [CI < 0]),\ THEN\ (R);$$
$$IF\ ([RI < 0]\ AND\ [CI \sim 0]),\ THEN\ (A);$$
$$IF\ ([RI < 0]\ AND\ [CI > 0]\ AND\ [PRT \leq PRT_{ac}]),\ THEN\ (LAC).$$

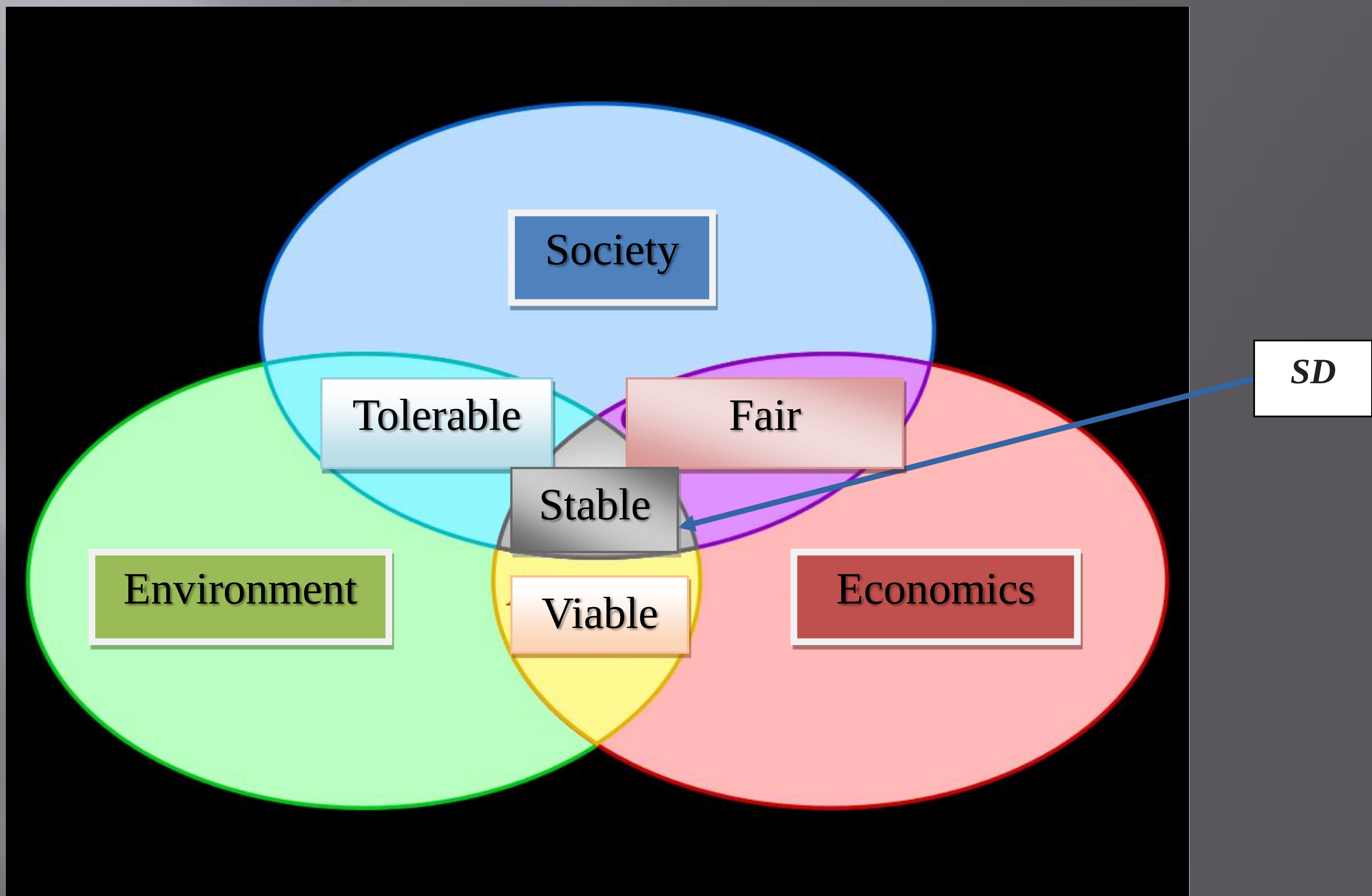
NM - new model;
D - development; *TNM* - transition to a new model;
R - reorganization;
CR - crisis;
A - adaptation;
RI - resource increment;
CI - connectivity increasing,
CS - conservation of the system;
LAC - local artificial crisis (reorganization of the local subsystem in order to adapt it to new conditions or requirements),
PRT - price of risk in the transition to LAC,
PRTac - the most acceptable *PRT* under some conditions.

Connections between the systems of different levels



r – development, *K* – conservation, *ω* – crisis, *a* – reorganization, *s* – restructuring

Conditions for the optimal ratio of Society, Economy and GeoEnvironment



SD = min {Env, Soc, Eco}

Env is determined by available resources ***AR,*** including

- alternatives,
- the presence of periodic cycles of changing conditions ***YC,***
- environmental capacity (the ability to accumulate undesirable components for the environment without negative consequences for it) ***AC,***
- migration capabilities (the ability of undesirable components to migrate outside the system) ***MG,***
- the ability to metabolize environmentally harmful components into more acceptable forms ***MT,***
- the status of a special area (e.g., reserve) ***ST,***
- population density ***PD,***
- building density ***BD,***
- the presence of natural sources of environmental pollution ***SE***.

Conclusions

The sustainable development of geological ecosystems depends on optimal ratio of society, economy and environment. Environmental component is determined by available recourses, including alternatives, environmental capacity , migration capabilities , population and building density, the presence of natural sources of environmental pollution etc.

Functioning of the complex system of geoecosystem can be presented as the model of “eight”, moreover its sustainable development depends on resources and connectivity.

All subsystems of geoecosystem are interconnected and require the adjustment of resources and connections, forming hierarchical set of "eights“ with micro- and macro- levels.