Application of Grouting Techniques for the Solution of Environmental Problems during Mining

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ABSTRACT

The interaction of man with the environment has a double character. From one side, mankind can not exist without consuming the natural resources and, from the other side, we actively alter and exert influence upon nature. Analysis reveals that the ecological problem is, to a great extent, a geological one. The paper deals with the application of grouting techniques to construct impermeable barriers for the protection of ground water and soils from depletion and industrial wastes pollution. A number of case histories in the field of mine construction is given to illustrate the solution of geotechnical problems in concert with environmental protection measures.

INTRODUCTION

At present we are in the situation when mining people all over the world are progressively facing environmental problems in their professional activities. Analysis shows that it is no coincidence. Mankind has gained comprehensive experience both in mining technologies and collected a great

scope of information, regretfully very often sad one, about the impact of mining activities on the environment.

The present state of the art of world mining industry provides capabilities to mine deep lying ore bodies and develop deposits most complex in mining and hydrogeological conditions. At the same time, the regulations of municipal and ecological bodies become more and more stringent. Undoubtedly, there is no alternative to the problem of environmental protection - mankind must do everything possible to neutralize negative impact of technological activities.

USE OF GROUTING TECHNIQUE IN PROVIDING ENVIRONMENTAL PROTECTION MEASURES

While assessing the potential of grouting technique in solving the environmental problem it is necessary to state the following. As it is known, ground treatment by grouting can be applied for sealing off underground excavations, consolidation of rock strata and filling karst or mined-out zones. During planning and implementation of grouting programs technical capabilities to predict accurately geometry and spacing of sealing covers, and control the processes of their formation can enable an engineer to adopt simultaneous application of a grouting scheme for the protection of environment. The essence of engineering solution in this will be the formation of interlocked or barrier covers in permeable or water bearing layers, and also in creating consolidated rock zones by grout injection treatment.

Certainly, the range of environmental problems which can be resolved by grouting technique will be limited still such a solution involves obvious advantages. First, by creating a sealing(grout) cover we attain what may be called the localization of mining activities zone from natural water bearing complex providing minimum impact on regional hydrodynamic balance. Moreover, if one employs the use of a chemically inert material there will be practically no

pollution of ground water caused by the processes of diffusion exchange and leaching. Our experience shows that stabilized grouts formulated on the basis of clay slurries and fine-dispersion pulps become the optimum materials in most cases (ready to meet also the requirements of workability and cost parameters).

Second, on the completion of grout cover formation surplus expenditures on further "maintenance" of this underground structure are eliminated. Finally, flexible application of the principle to develop grout formulations for each particular case can assist in effective solution of problems associated with the utilization of ore processing wastes especially while undertaking large-scale projects.

Research and feasibility programs into this field accomplished by the STG Company and their wide industrial application enable us at present to provide the following services in environmental protection:

- protection of water bearing formations from depletion by reducing the rates of ground water discharge in operating drainage systems,
- prevention of aggressive mine water disposal by constructing sealing curtains around open pits and mines,
- protection of ground surface from subsidence resulting in the course of ore extraction, karstification processes and dewatering by filling subsurface voids and caverns with grout mixtures,
- protection of aquifers by screening covers from infiltration of contaminated water (coming from settling and tailings ponds, hydraulic mine dumps, water courses containing industrial wastes etc.),
- encapsulation of contaminated zones in aquifers and sealing of underground storages, sewage systems/service line headers by constructing interlocked or barrier grout covers.

Following are some case history brief reports that have been chosen to illustrate the various forms of grouting used for environmental protection objectives.

CASE HISTORIES

Commissioning and production life of mining enterprises involve intensive discharge of ground water through operating drainage and disposal systems with the formation of industrial wastes basins. This results in considerable changes of hydrodynamic and chemical regimes of adjacent regions that, as a rule, will cause depletion of groundwater resources and deterioration of its sanitary indexes.

To provide the protection of ground water from depletion, the sinking of mine shafts in the Donetz Coal Basin and some other coal mining regions in the USSR is carried out employing the use of grout covers. Such covers are preliminary formed in aquifers and abandoned workings within the total depth of future shafts through directional holes drilled from ground surface. Such practice eliminates the need to perform dewatering by maintaining depression cones.

For example, the sinking of two shafts of the Yuzhnaya Mine through water-logged abandoned workings (Fig.1) had been first planned with high-capacity pumping. With the objective to cut down the cost of pumping and preserve the natural balance of ground water the project report was revised to design a pregrouting program. Shaft sinking is now completed with the natural hydrodynamic balance maintained.

Large water bearing fault zones discharging inflows up to 2000 cu. m per hour are often encountered during drivage of major workings. Dewatering of such zones will destabilize the regional hydrodynamic regime and result in increased mineralization of surface water reservoirs. To enable safe intersection of large fault zones there has been developed an innovative technique to pregrout the faults leaving all

grouting equipment on the ground surface.

At one of the mines in Donbass area, USSR a haulage drift was driven using pumping for water control. However, three years of pumping more than 1 mln. cu. m of water resulted in the reduction of inflow from 200 cu. m/hr to only 100 cu. m/hr. Further activities were continued on the basis of grouting program designed by the STG Company (Fig.2) on the completion of which the drivage operations were successfully finalized.

Development of some kimberlite deposits in Yakutiya area, USSR in permafrost strata is complicated due to occurrence of highly saline ground water which does not freeze even under rock temperature up to minus 8°C.

The occurrence of thick artesian brine aquifers and ecological problems associated with this preclude from the application of conventional water control techniques for opencasting. Under such conditions dewatering, for example, will be not effective since preliminary of brines involves the construction of costly and laborious installations.

Feasibility studies into this field proved the effectiveness of sealing covers around such type of deposits using the implacement of low-temperature stabilized or freezing grout mixtures. Their formulations include clay suspensions and processing plants slimes, additives of special reagents and setting agents. At present the implementation of one such project is in progress. Preliminary estimates show that water control by grouting technique will be four times cheaper than the construction of a dewatering system, and the program can be accomplished within the period of 4-5 years. This scheme resolves also the problem of environmental protection and further development by underground mining (Fig.3).

Special grouts and process patterns to meet the conditions of high mineralization and magnesian aggression of ground

water were used during the restoration of workings inundated by ground water brines in the property of Stebnick Potash Plant, Western Ukraine (Fig.4). The inrush of brine with a discharge of 340 cu. m per day into two chambers of the 140-m level resulted in intensified karstification processes which lead to ground subsidence with the formation of 15-m dia. sink holes. Further increase in brine discharge and karst formation endangered the existence of the mine.

To seal off the inrush of ground water and stop further subsidence, there were drilled several series of grouting holes at a depth from 75 m to 140 m through which the designed quantity of special grout was injected. As a result, the situation was normalized, mining operations were resumed and ground subsidence completely stopped.

To protect farming lands from ravine erosion, the STG Company has developed and introduced at several projects in the Moscow-Region Coal Basin a technique for the prevention of quick sand inrushes into mine openings that had been accompanied by rock strata deformation, ground subsidence and formation of a system of ravines spoiling farming areas.

During drivage of the eastern branch of the shaft insets at the 70-m level of the Belkovskaya Mine the inrush of water-sand-clay mass with a discharge of 180 cu. m per hour occurred. It resulted in the outflow of more than 2000 cu. m of water saturated material into the mine workings. The grouting scheme comprised ground treatment through holes drilled into the overlying layer. Grouting holes were intersecting the voids from 2.5 to 6.2 m wide. Grout composition was formulated on the basis of local loams. Prior to the commencement of grout implacement interhole acoustic sounding had been conducted to determine the boundaries of voids propagation. On the completion of grouting program the drivage operations were resumed.

CONCLUSIONS

The problems of environmental protection and rational utilization of ground water resources are characterized by complexity and multiplicity of aspects. Naturally, their effective solution will require further programs of feasibility studies and research into the field of accurate forecasting and control proceedings dealing with technological impact on nature.

Taking account of this the application of specialist techniques with an objective to simultaneously provide environmental protection measures seems to be a rational approach efficiency and advantages of which can be proved by successful experience in the employment of grouting methods.

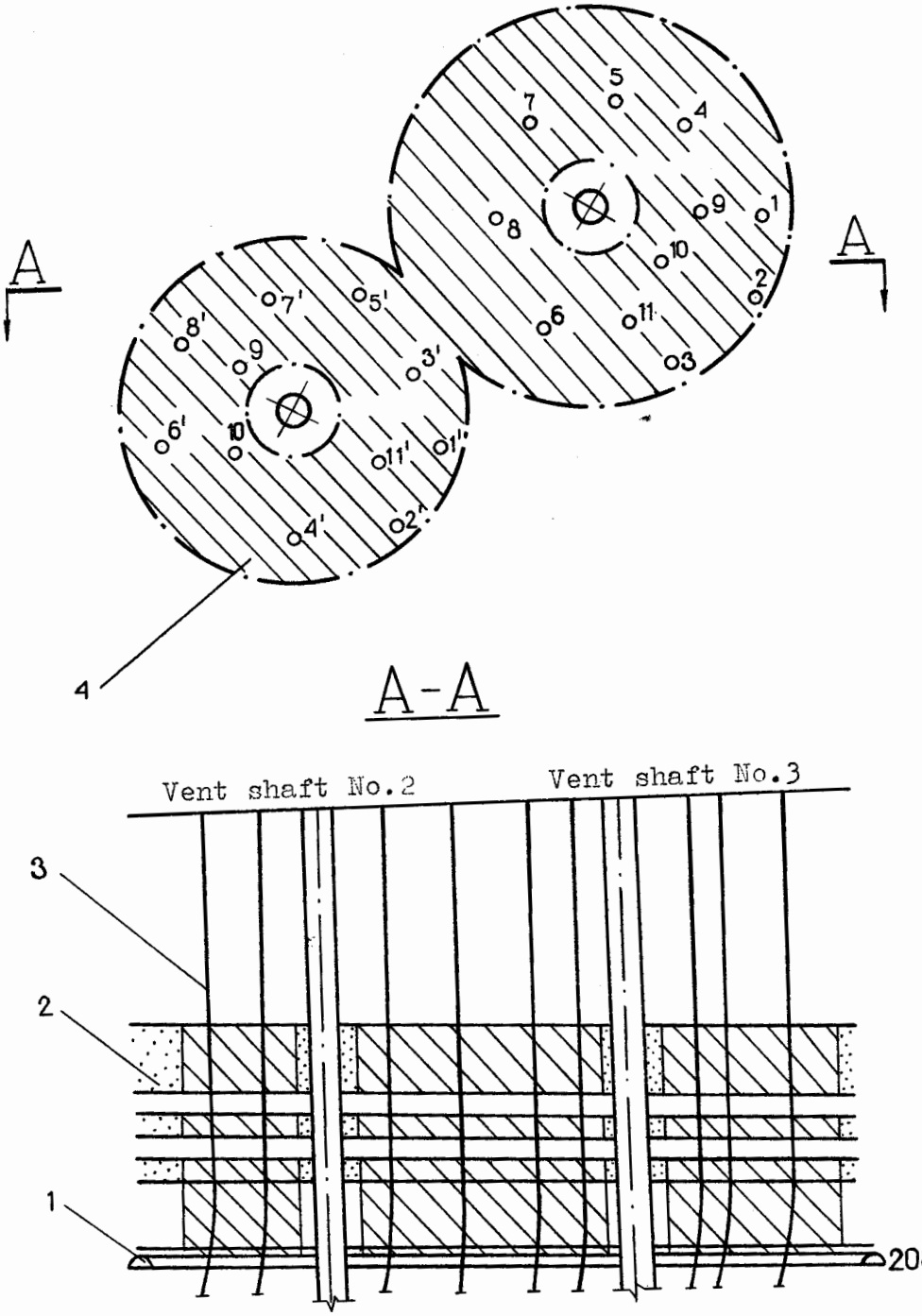

Fig. 1 Grouting procedure for abandoned workings around mine shafts of the Yuzhnaya Mine

1-water-logged abandoned workings, 2-water bearing strata, 3-grout holes, 4-grout cover

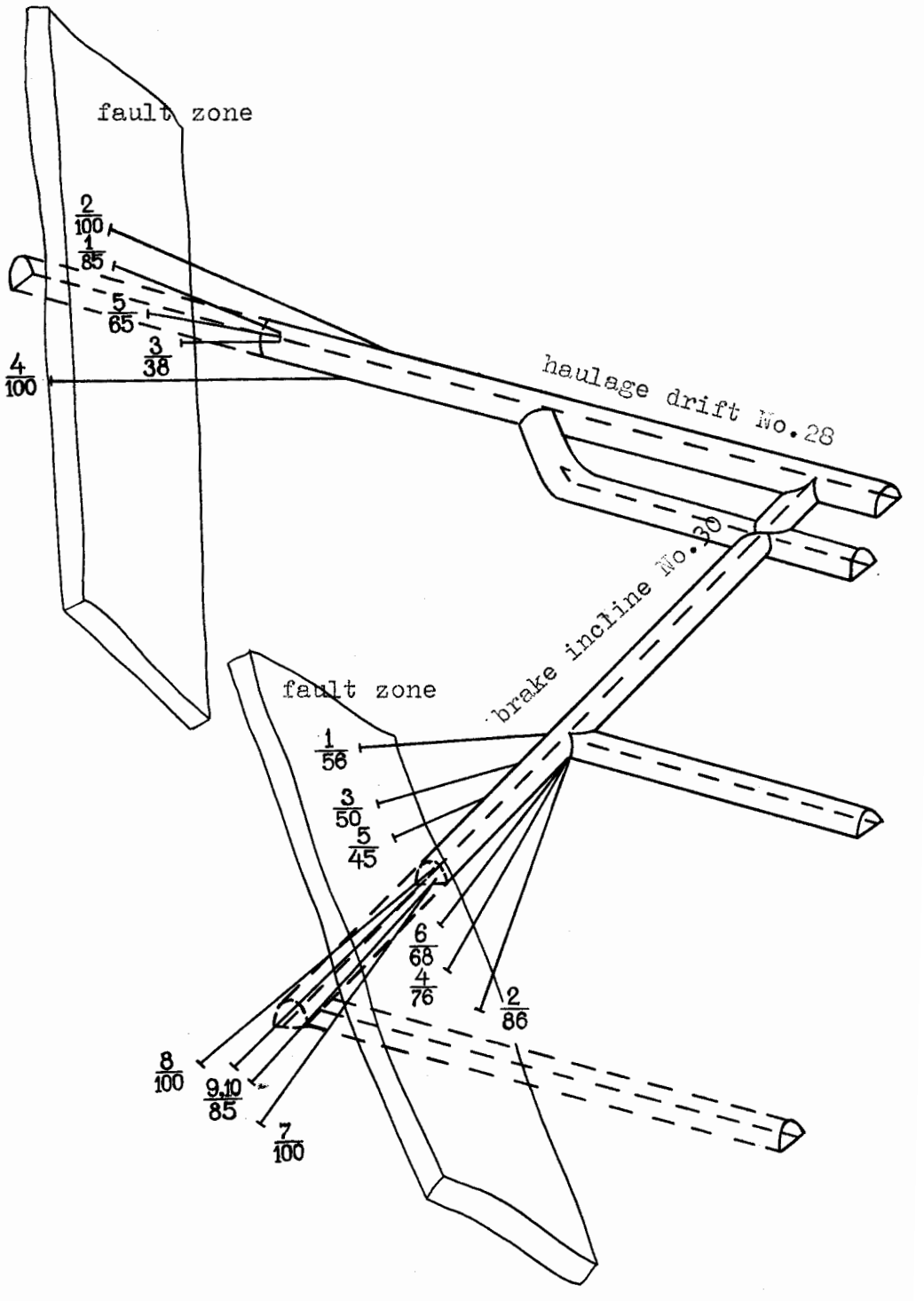

Fig. 2 Pregrouting procedure in driving development workings

$\frac{8}{100}$ - number and depth of grout holes

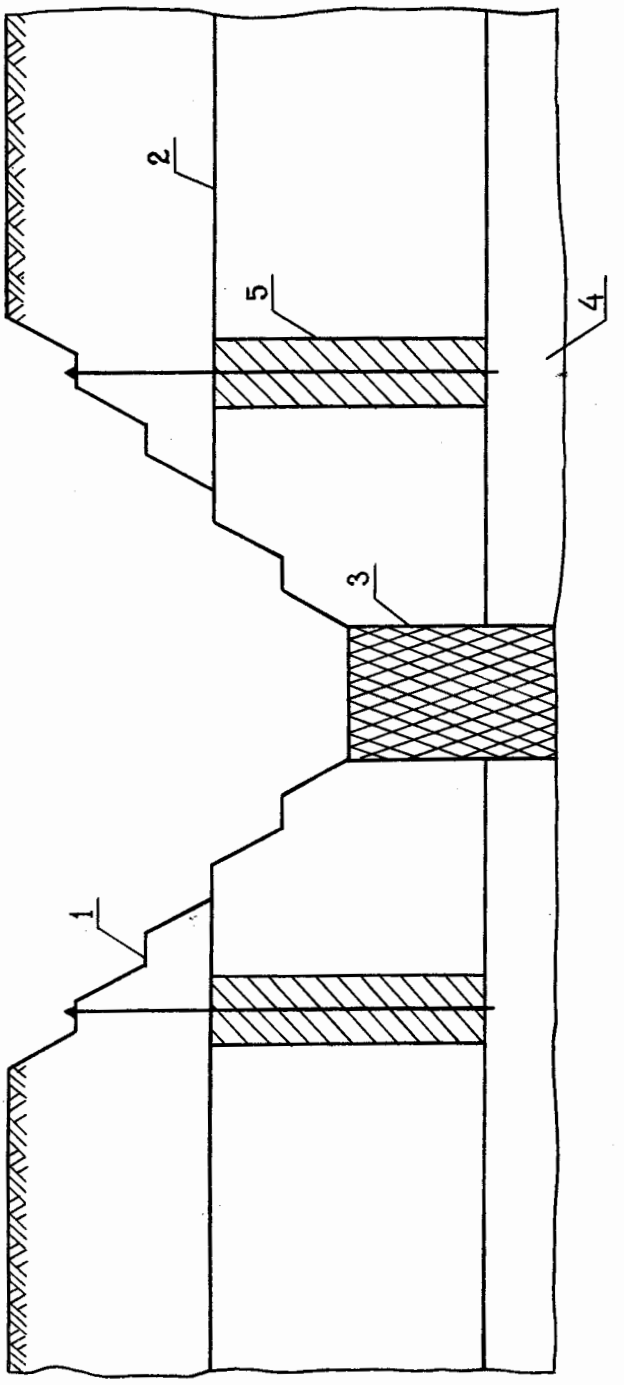

Fig. 3 Arrangement of sealing curtain around an opencast
1-opencast bench, 2-water bearing zone, 3-ore body,
4-water resisting strata, 5-sealing curtain

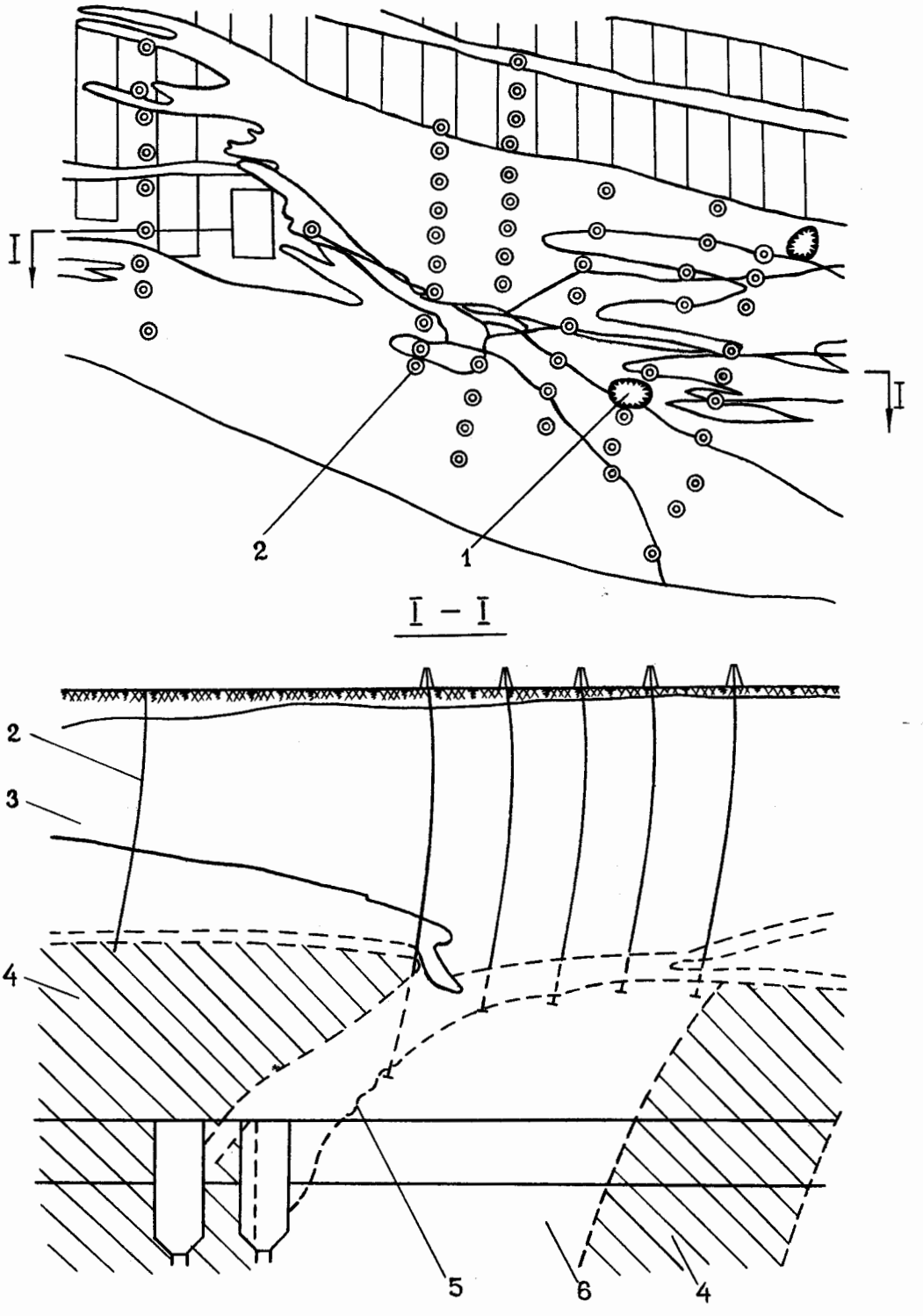

Fig. 4 Grouting scheme used during restoration of productive chambers at Stebnik Potash Plant

To Fig. 4 :

1-ground subsidence zones
2-grout hole
3-mudstone/gypsum rock
4-ore body
5-karst voids
6-brine bearing fractures