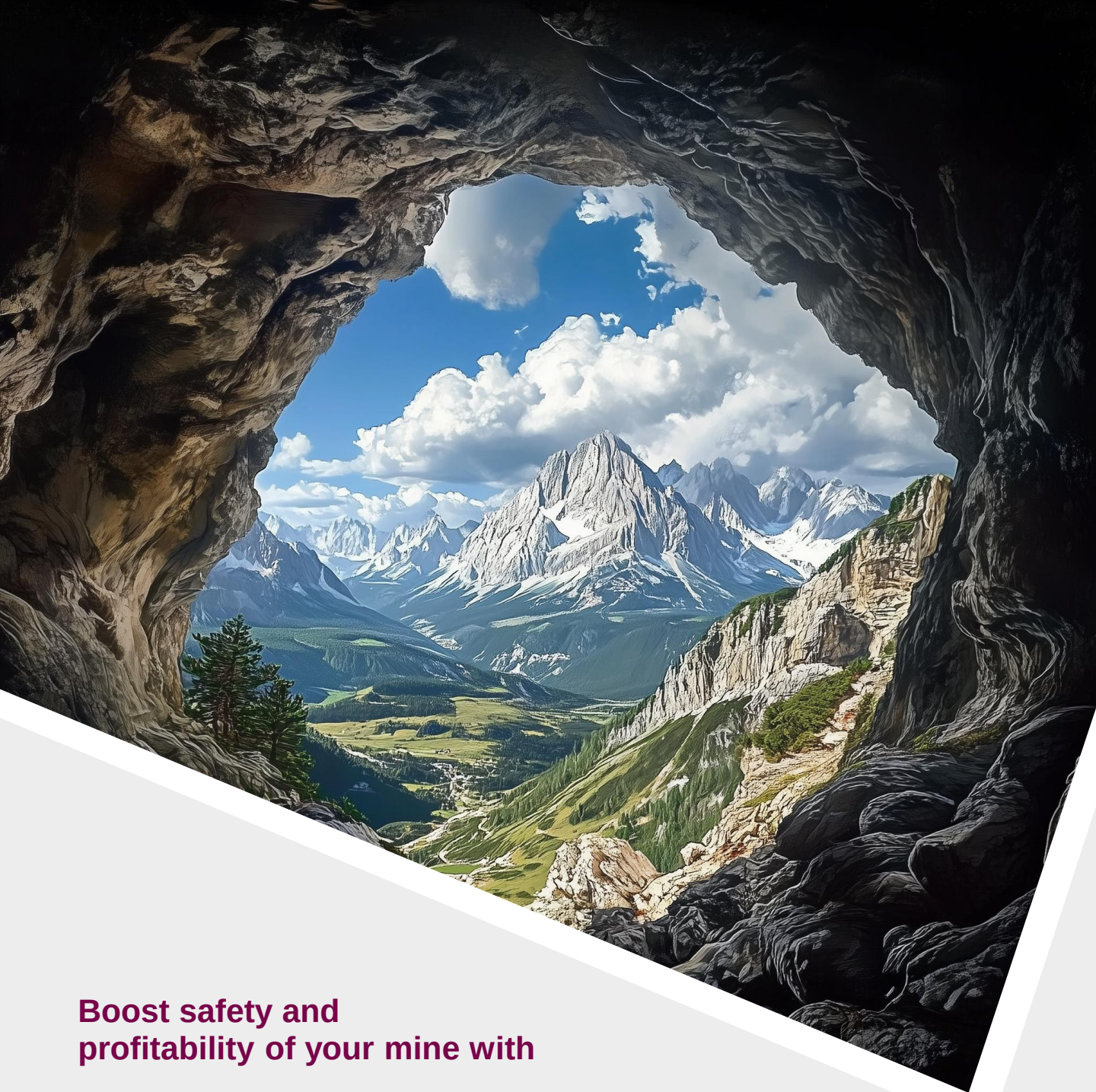




Boost safety and
profitability of your mine with

BACKFILL using mining residues

- ▶ STABILISATION OF THE MINE
- ▶ REDUCTION OR ELIMINATION OF STOCKPILES
- ▶ HIGHER ORE RECOVERY BY PILLAR REPLACEMENT

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BACKFILL SERVICES

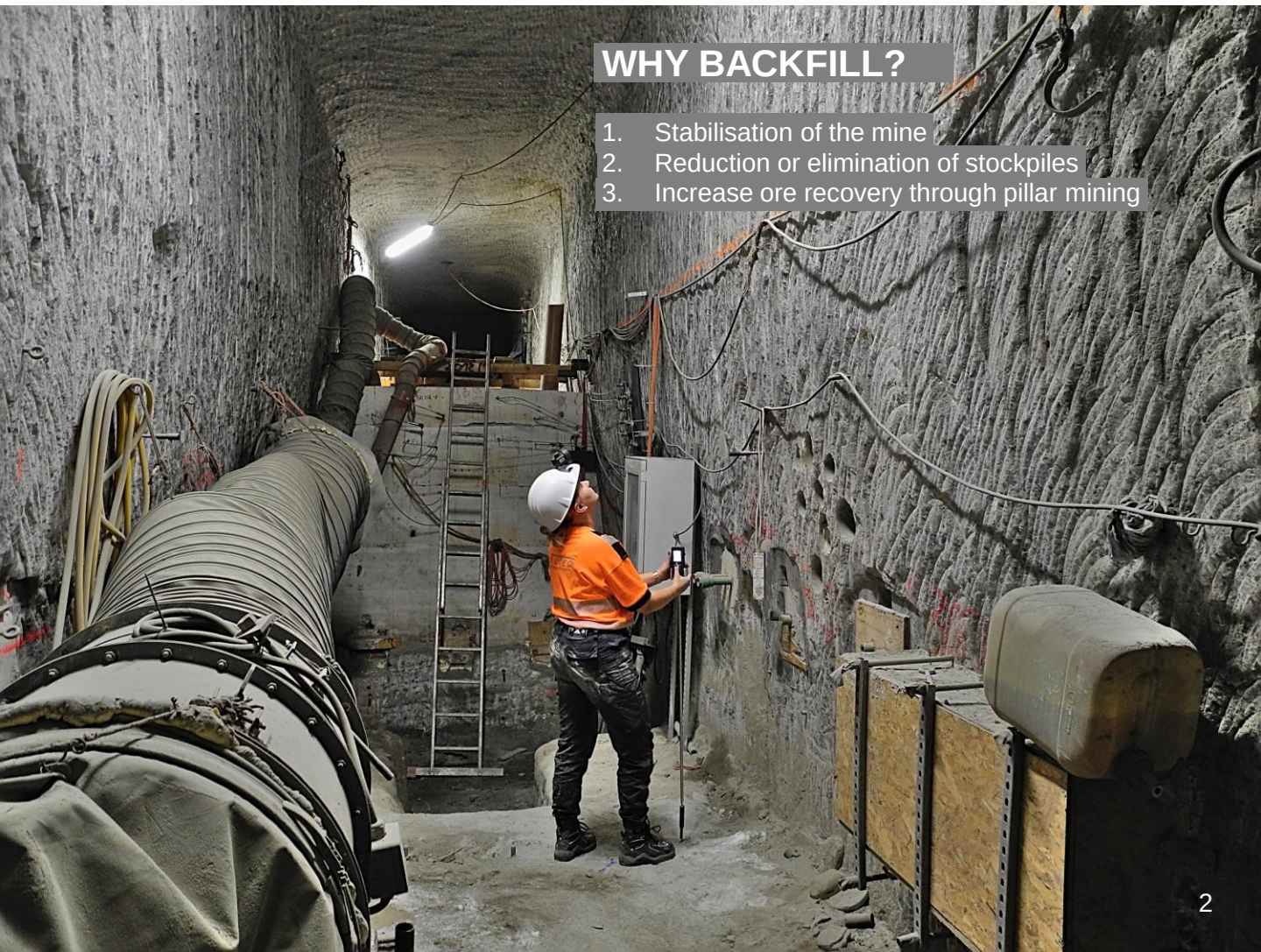
K-UTEC: THE IDEAL BACKFILL PARTNER

Mining not only extracts valuable materials, but also produces mining residues. The latter include, for example, residual sludge from processing ("tailings"), waste rock extracted together with the ore and rock from the excavation of drifts.

The typical key question is, what to do with the residues? Firstly, it should always be attempted to recover secondary, valuable materials from the residues ("waste to value"). Nevertheless, the majority of the residues are usually disposed of either above ground in stockpiles or underground as backfill. In our modern environmentally conscious world, permanent large stockpiles need to be reduced as much as possible or even eliminated if possible. As a consequence, backfilling is playing an increasingly important role.

Today, backfill often forms an integral part of the „social license to operate“. For new projects, a detailed backfilling concept must be submitted to the authorities already during the planning phase in order to obtain authorisation for the mining project.

K-UTEC is one of the few specialised service providers in the world that can provide you with comprehensive backfilling support: From material suitability testing, recipe development, stability analyses and plant planning to the preparation of approval documents. We have more than 70 years of experience in backfilling. In our highly specialised backfilling laboratory, we perform all tests and investigations ourselves and can also process and fulfil clients' special requests in systematic test series.



WHY BACKFILL?

1. Stabilisation of the mine
2. Reduction or elimination of stockpiles
3. Increase ore recovery through pillar mining

BACKFILL STABILISES THE MINE

Backfilling is used to stabilise mine workings and therefore fulfils an important geomechanical safety task. In contrast to this is the underground storage facility, which has no stabilising purpose but is primarily aimed at safe underground storage.

We take care of your backfill planning regardless of which raw material you are mining. Whether salt, mineral ore or coal, K-UTEC is always the right partner for you. We offer you the choice between different backfill types and methods. Whether liquid or solid, K-UTEC is able to provide you with expert advice on backfilling solutions of all kinds. Our portfolio includes, but is not limited to, hydraulic backfill, paste backfill, cemented backfill and big bag backfill.



RESIDUE MANAGEMENT FROM A TO Z

We offer comprehensive residue management. We go to the source and take a close look at where and how the residues are produced. In greenfield projects, we first produce the residues in a targeted manner. This enables us to precisely characterise them chemically, mineralogically and physically and to experiment with them in order to develop customised backfill formulations. We plan the surface and underground transport routes.

How do the residues get to the backfill plant? How do they have to be processed in order to be used as backfill material? What equipment is needed for this? And how is the finished backfill then transported to its place of use underground? K-UTEC plans the entire process and all process steps for you on a project and site-specific basis in order to produce high-quality backfill from mining residues that effectively stabilises the mine workings.

INDISPENSABLE: THE BACKFILL LABORATORY

Our backfill laboratory is quite special. There are only a few facilities of this kind in the world. In our lab you will find a wide range of specialised equipment that is precisely tailored to the needs of backfill testing. We have trained our employees specifically for this task, as backfilling is not a standard degree programme or apprenticeship. This valuable knowledge has been passed down from generation to generation for more than 70 years. The work in the laboratory can be divided into three steps:

Step 1: Comprehensive analysis of the residues

Firstly, we test the chemical and physical properties of the residues in our construction materials testing laboratory. Are the materials suitable at all for underground use? Is outgassing to be expected? The measured values provide important fundamental information for further planning. Which positive properties of the residues are present or can be specifically induced in the process, e.g. binding properties?

Step 2: Development of customised backfill recipes

The residues need to be turned into backfill. A binding agent often needs to be added to ensure that the backfill achieves the desired strength in the short to medium term. In hydraulic processes, the backfill mixture may only harden after a delay, otherwise the backfill pipeline would clog. Recipe development is a matter of optimisation. The use of specifically purchased, additional materials should be minimised in order to reduce costs and achieve a process that is as economically as possible. We carry out the necessary market analysis for you. Furthermore, the ingredients used in the backfill mixture must be compatible with each other. Undesirable reactions between the individual ingredients must be prevented from the outset. Recipe development therefore requires a great deal of skill and experience, just like cooking.

Step 3: Checking the backfill properties

Once the initial mixture has been successfully produced, the backfill is put through its paces in the laboratory. Does the backfill fulfil all the desired criteria? How long does the backfill need to harden? What strength (uniaxial compressive strength, UCS) and stiffness (Young Modulus) does the material have? What is the chemistry of the associated liquid or eluate? Nothing is left to chance here. Before the backfill formulation is used in the mine, extensive testing of the backfill takes place in the laboratory.



PLANNING OF BACKFILL FACILITIES

The commissioning and authorisation of a mine with backfilling requires thorough planning. Design of the surface and underground backfill facilities is an essential element in the approval process and must be created individually for each mine. Mine planning, ore processing, mass and volume balance, equipment selection and other components play a decisive role. We work both for greenfield projects, and for existing mines in which backfill components are being newly introduced.

We calculate and plan for you. We provide support in the preparation of planning documents and environmental authorisation procedures. We work closely with the mine planners to ensure that the backfill systems and processes are seamlessly integrated into the overall mine planning. K-UTEC carries out concept studies, e.g. Pre-Feasibility (PFS), Definitive Feasibility (DFS), Bankable Feasibility (BFS), Basic Engineering (BE), Process Design and Detailed Engineering. We prepare your tender documents, help you with selecting the best equipment suppliers, and support you with the commissioning of the backfill system.



PLANNING OF UNDERGROUND DAM STRUCTURES

To place hydraulic backfill, the roadways and excavation areas to be backfilled must be separated from the rest of the mine by dams. The flow barriers must be made of particularly resistant material in order to prevent dam failures and unwanted flooding. K-UTEC has many years of experience with underground dam construction materials and their installation. We can help you with the planning, supervision and monitoring of dam structures.

GEOMECHANICAL CALCULATIONS OF BACKFILL

In addition to the laboratory tests, geomechanical calculations are necessary to ensure that the backfilled areas are able to fulfil their support function. Large-scale geometries and long periods of time are taken into account. We prepare long-term safety analyses and risk assessments. We inspect the mines at regular intervals to document the status and identify potential risk zones.

$$a_n = \frac{1}{L} \int_0^L f(x) \cos\left(\frac{n\pi x}{L}\right) dx$$

$$C_n = \frac{1}{2\pi} \int_{-\infty}^{\infty} f(t) e^{-jn\omega t} dt$$

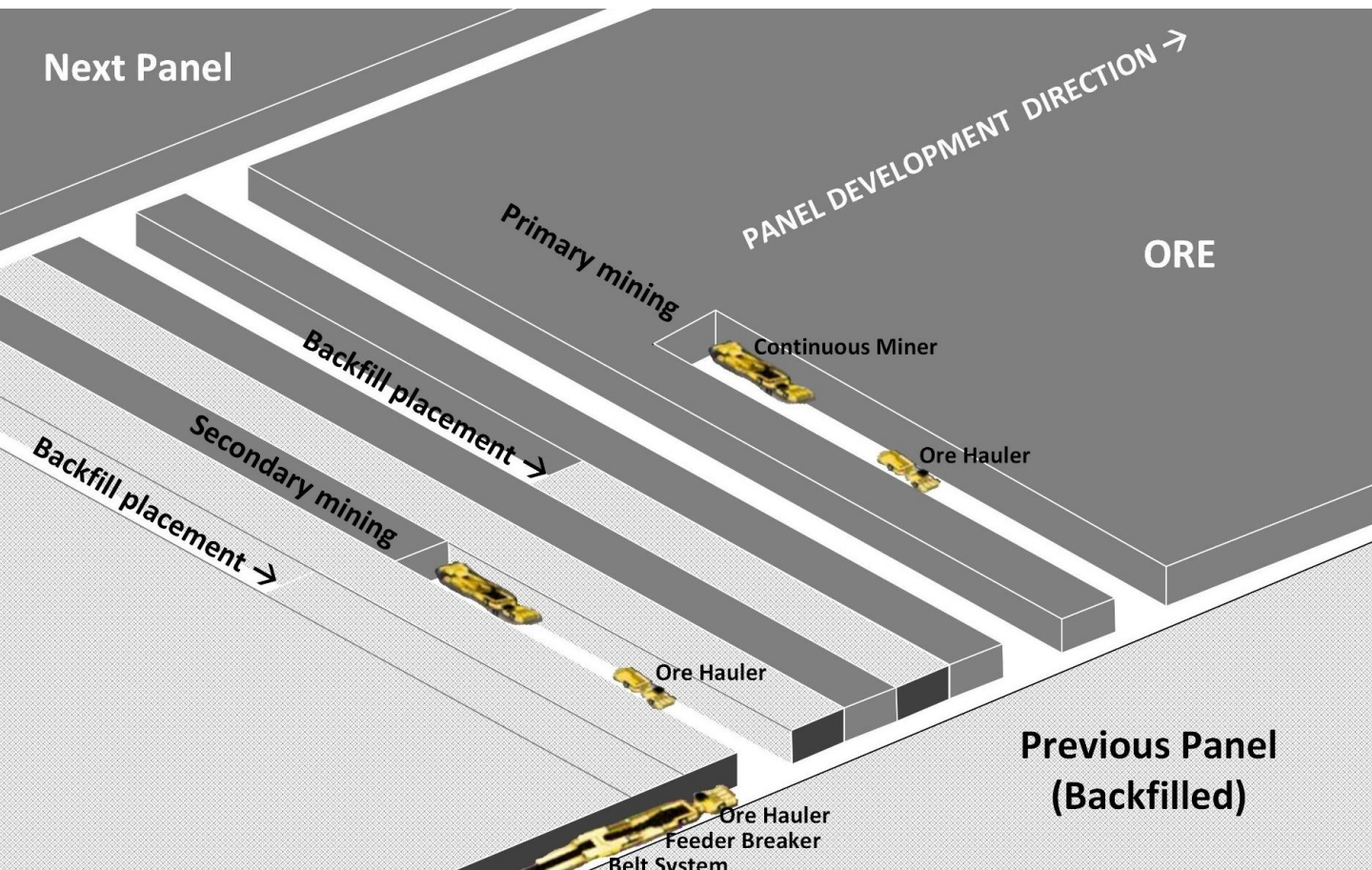
$$b(\omega) = \frac{1}{j\omega} \int_0^{\infty} f(t) \cos(\omega t) dt$$

$$f(t) = \sum_{n=-\infty}^{\infty} C_n e^{jn\omega t}$$

$$C(\omega) = \int_0^{\infty} f(t) e^{-j\omega t} dt$$

HIGHER ORE RECOVERY BY MINING PILLARS

A significant proportion of the ore often remains underground in the form of pillars, which are intended to support the mine workings (e.g. in room and pillar mining). Intelligently planned backfilling can take on supporting functions so that the pillars and their ore can be extracted during a secondary mining phase. This approach leads to a significantly ore recovery compared to traditional mining methods without backfill. K-UTEC helps with the recipe development of the backfill material and the selection of the backfill method. Pillar mining can significantly increase the economic efficiency of mining. We are at your side to advise you on how you may benefit from pillar mining, without jeopardising the safety and stability of your mine.



REFERENCES & CONTACTS

PROJECT REFERENCES (SELECTION)

- Development of a backfill concept (PFS) for a hard rock lithium project for Zinnwald Lithium (Germany)
- Development of a basic engineering concept for a tailings management system and design of the backfill infrastructure with testwork in the Muga project for Geoalcali (Spain)
- Concept study for the development of backfill mixtures and adaptation of the existing process for Kazzinc (Kazakhstan)
- Planning of disposal and backfilling systems for the surface and underground disposal of hazardous waste in gypsum mines and a salt mine for Tellus Holdings (Australia)
- Feasibility study for the development and optimisation of backfill recipes and for a backfilling plant and infrastructure for a cavern customer in Central Europe
- Recipe development and backfill concept for $MgCl_2$ tailings in Nivenskiy-1 potash SOP project for K-Potash Service (Russia)
- Technical concept (scoping design) for storing processing water from the Werra plant in the Springen mine field for K+S (Germany)
- Development of backfill and engineering concept for paste backfill, test work, Scoping Study and PFS for South Harz Potash (Germany)

CONTACTS

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K-UTEC: WHERE INNOVATION MEETS TRADITION

K-UTEC is a renowned and innovative service company for the global mining and raw materials industry, which was founded in 1951 as a state research centre and privatised in 1992. Our headquarters are located in Sondershausen in the heart of Germany, a place with a mining history of more than 135 years. Our campus (white buildings) is located in the immediate neighbourhood of the historic Petersenschacht, which was built in 1910 to expand the local potash mine. We operate worldwide and are supported by a network of national and international partners.



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