
# SIKA AT WORK
# KASSANDRA MINES, GREECE

SHOTCRETE PRODUCTION / TANK WATERPROOFING / ANCHORING & GROUTING / JOINT SEALING / INDUSTRIAL FLOORING

BUILDING TRUST

# KASSANDRA MINES – FULL PRODUCT RANGE FROM SIKA

**PROJECT DESCRIPTION**
Hellas Gold S.A. is a gold, silver, lead and zinc mining company headquartered in Athens, Greece. Since 2004, Hellas Gold operates the "Kassandra Mines" assets at N.E. Halkidiki, under the strictest EU safety and environmental standards and regulations. The Kassandra Mines consist of: Stratoni and Olympias operating mines, and the Skouries project.

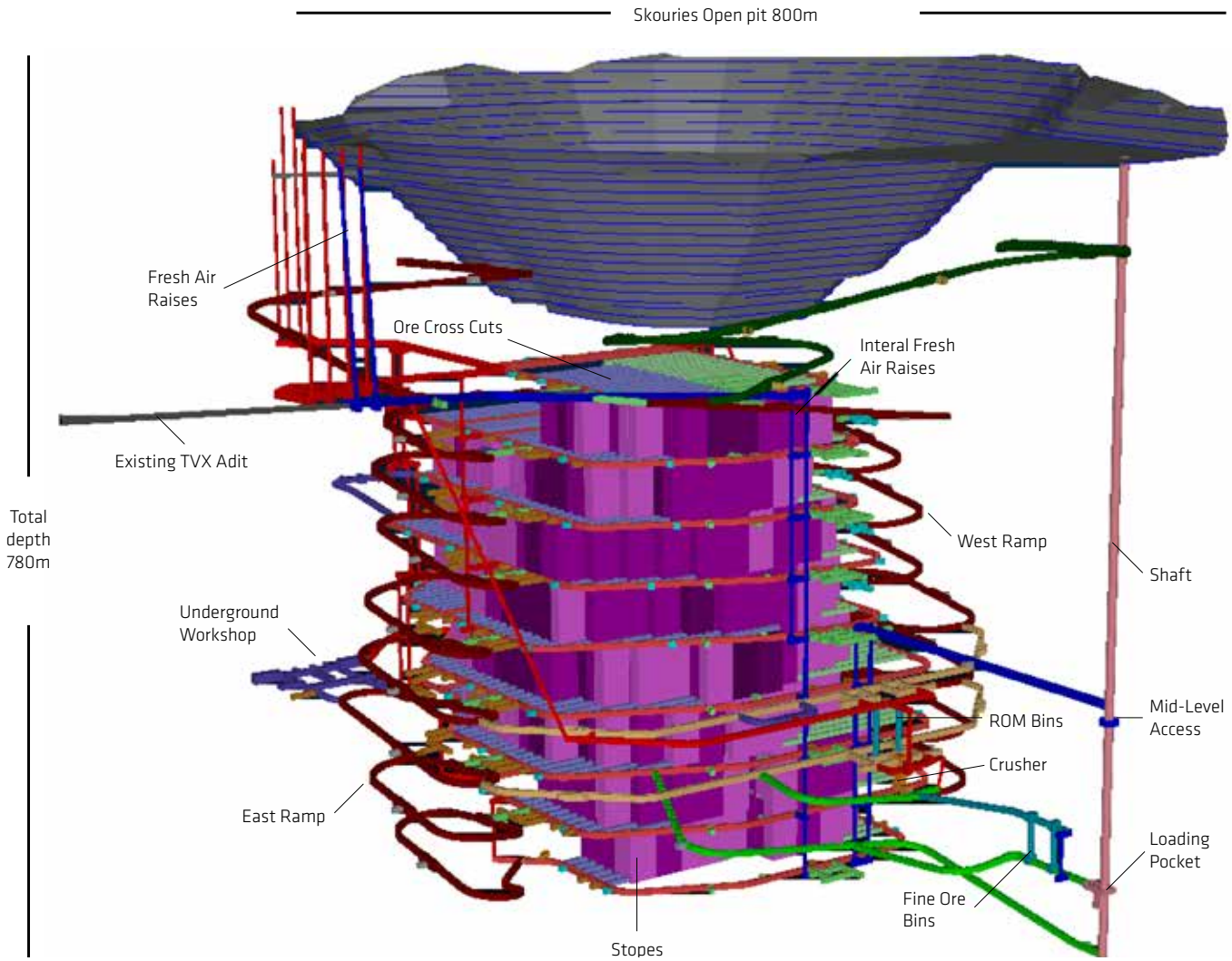
Evolving a mining history of 25 centuries, Hellas Gold invests in the development of sustainable mining in the region, contributing to the local economic growth and prosperity with investments of more than $1 billion, the employment of about 2,000 people, the active support to the local suppliers, and important investments to local community initiatives and projects. Since 2012, Hellas Gold operates as a subsidiary of the Canadian-based Eldorado Gold Corporation, which has over 25 years of experience in exploration, construction and operation of mines around the world.


The stratoni-olympias decline portal and ventilation equipment.

**PROJECT DEMANDS**

**Olympias Mine:** Olympias is an existing gold-silver-lead-zinc underground mine. The mine is being redeveloped and modernized in phases. Phase I involves an environmental clean up of previously mined tailings (mining waste) and the refurbishment of the original processing plant and underground mine. It started in 2013 and continued during 2017. Phase II began in the first quarter of 2017, with the commencement of underground production alongside operation of the Olympias flotation plant. The upgraded flotation plant and the modernized underground mine were officially declared in commercial production at the end of 2017.

**Stratoni mining facilities:** Stratoni is an underground, silver–lead–zinc mine. The Stratoni mining area is composed of the Mavres Petres underground orebody, the Stratoni plant and the Stratoni port facilities. Ore from the Mavres Petres mine is transported to the Stratoni plant where, through a multi-stage flotation process, a lead-silver concentrate is produced.




Mine layout of the Skouries open pit and underground project.

# KASSANDRA MINES – FULL PRODUCT RANGE FROM SIKA

For the period 2006 – 2013, a total of € 50 million were invested in upgrading and modernization projects.

**Skouries Project:** Skouries is a high-grade gold–copper porphyry deposit. Upon completion, the Skouries Project will operate initially as an open-pit and underground mine, later followed by only underground production. Hellas Gold's objective for the Skouries Project is to use the smallest possible surface area for construction of the mine.

The two-component, liquid, hot-spray, polyurea based membrane Sikalastic®-843 GP is applied at the surface reservoir of the Kokkinolaka mine.

SikaFix® injections to counter water ingress underground.

Sika® Sigunit® shotcrete accelerators and concrete admixtures are used for all of the Kassandra undergorund operations and allow rapid mine cycle times for fast underground development.

Discussing the support strategy of the Stratoni-Olympias decline.

**SIKA SOLUTION**

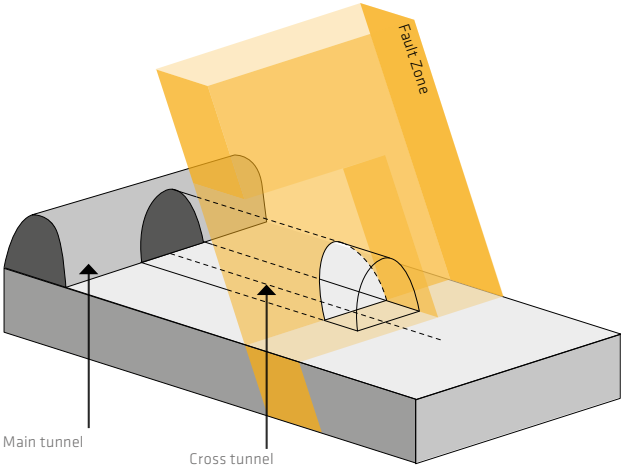
Sika has been actively involved in the supply of specialized products since the beginning of the project. A multitude of materials and systems were required for each construction phase. Below we list the most demanding cases for addressing key issues for project progress.

**Shotcrete production:** Mining projects require the development of several kilometers of underground drifts. The underground support consists of shotcrete, which has to meet increased efficiency requirements (high early & final strengths, improved pumpability), cost requirements (optimized composition, reduced rebound), but also ecological requirements (use of non-toxic admixtures). To meet these requirements, Sika has provided special plasticizers and accelerators with the best combination of performance vs cost. One of the main issues that had to be addressed in designing and handling of the mix was the increased thixotropy of the shotcrete, a feature that was particularly improved with the incorporation in the mix of the special superplasticizer designed for shotcrete Sika® ViscoCrete® SC-360. The tests on site under real construction conditions confirmed the improvement of the pumpability of the mix, facilitating the concreting process, making it faster and with reduced equipment wear (shotcrete pumps). In addition, the use of Sika® ViscoCrete® SC-360 superplasticizer made it possible to reduce the water content of the mixture (active water / cement ratio) and reduce the amount of cement without loss of the early and final strengths, reducing rebound at the same time, significantly improving the cost-performance of the shotcrete. The high environmental management, hygiene and safety requirements of the project required the use of an alkali-free shotcrete accelerator. Thanks to the optimization of the mixture with Sika® ViscoCrete® technology superplasticizers, it was possible to use Sigunit® AF alkali-free accelerator at very low dosages. On-site tests have confirmed that the finally produced mix with Sika admixtures fully meets the high requirements of EN 14487-1.

The Skouries processing plant under full construction showing the SAG- and Ball mill installations and foundation construction using a wide range of Sika construction products.

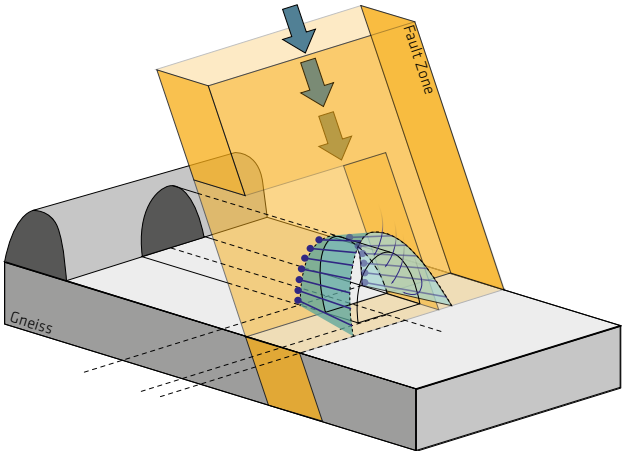
# KASSANDRA MINES – FULL PRODUCT RANGE FROM SIKA

**Suspension of water penetration/Waterproofing:** During the tunneling phase in the Stratoni area, there was a severe problem of water inflow. The auxiliary tunnel, which was to be constructed perpendicular to the main tunnel, aiming to be used as a reversing area for trucks, entered a troubled crushed rock area with a large flow of water of 200 $m^3/h$. Due to the inclination of the main tunnel (10°) all was diverted to the decline face, creating serious delays and pumping costs and effected the advance rate of the decline construction.




Intersecting a problematic, water bearing fault zone during a cross-cut construction along the Stratoni-Olympias decline.

In addition Sika also had additional challenges to face. Many previous injection procedures stabilized the substrate but blocked the existing injection routes and caused additional inconsistent cracks. As the rock substrate was covered with shotcrete, it was difficult to identify the water bearing structures. Hence, Sika had to stabilize a partially stabilized but none visible substrate. The location of most of the holes indicate that they were drilled behind the main "water duct" responsible for the large water inflow to the left of the tunnel.




Drilling a injection umbrella using SikaFix® injection resin to block water ingresses.

## CROSS TUNNEL FRONT

Unsuccessfully drilled injection holes prior to Sika injection process.

Following an assessment of the current situation, Sika's waterproofing plan was to form a sealing injection umbrella (green section on the graph) around the transverse tunnel inside the crushed zone. With the "drill-inject-drill" method, the incoming waterfront was progressively moved to the top of the front, where the final injections were performed and the water ingress finally reduced to insignificant volumes.

The two-component polyurethane injection system SikaFix®-210 was used in the low-medium water penetration areas, while in the areas with increased water penetration, SikaFix®-210 was combined with the SikaFix® AC-21 accelerator providing very fast reaction times once in contact with water. The SikaFix® injections expansion rate, their high mechanical strength for pressure resistance and their high penetrating ability have been the decisive factors for the success of the application.

Shotcrete spray application using Sika® Sigunit® accelerator technology.


Observing the injected face with the stoped water ingress.

# KASSANDRA MINES – FULL PRODUCT RANGE FROM SIKA

Application of the two-component Sikafloor®-161 epoxy primer followed by Sikafloor®-161 scratch coat.

Spray application of Sikalastic®-843 GP in progress.

**Waterproofing of the Kokkinolakas reservoir:** For the processing of the ores, it was necessary to seal the 1,680 $m^2$ surface reservoir of the Kokkinolaka mine, in which the water from the Kokkinolaka dam in the area of Stratoni is being driven finally. The waterproofing process should take place with a coating resistant to mechanical stress – due to the use of mechanical equipment for its scheduled maintenance – as well as against chemicals. For the waterproofing Sikalastic®-843 GP spray system was applied, a pure polyurea based liquid waterproofing membrane. Its short curing time and its almost instantaneous space utilization combined with its large service temperature range (-30°C to + 100°C) and its excellent crack bridging ability have been just a few of the benefits that have been taken into account for selecting this system.

Spray application of Sikalastic®-843 GP using a two-component pump.

The floor substrate was smoothed with a single disc machine equipped with polycrystalline diamonds, suitable for concrete substrates. The internal walls were smoothed with angular wheels with diamond discs.

This was followed by water jetting in order to remove the dust. Subsequently, a three-component micromortar, based on cement and epoxy resins was applied to smooth out any irregularities of the surface. Sikagard®-720 EpoCem® was then applied for finalsurface smoothing of the reservoir floor. On the perimeter walls, the two-component Sikafloor®-161 epoxy primer was applied first, followed by Sikafloor®-161 scratch coat.

The main waterproofing of the reservoir was performed using the two-component, liquid, hot-spray, pure polyurea based Sikalastic®-843 GP membrane, up to the height of the handrails.

The two-component acrylic-polyurethane final paint with weather-resistant SikaCor® EG-5 was applied to the entire surface of the water-free reservoir and exposed to UV radiation (from the height of its upper water level and the handrail, about 1 m below the rim of the tank).

# KASSANDRA MINES, GREECE

Application of SikaFix®-210 using a two-component pump and compressed air from the mine.

**SIKA PRODUCT QUANTITIES:**

- Sika® ViscoCrete® superplasticizers
- Sika® ViscoFlow® superplasticizers
- Sika® ViscoCrete® SC special superplasticizer for shotcrete
- SikaTard®-930 cement hydration stabilizer
- SikaFiber® PP 940-50 polypropylene fibers
- Sigunit® alkali accelerator
- Sigunit® AF alkali free shotcrete accelerator
- SikaFix®-210 polyurethane injection
- SikaFix® AC-21 accelerator for polyurethane injection
- Sikafloor® QuartzTop mineral surface hardener
- Sikafloor® Proseal-W curing compound and sealer
- Sikaflex® polyurethane sealants
- Sikafloor®-161 two-component epoxy primer
- Sikagard®-720 EpoCem® three-component micromortar
- Sikalastic®-843 GP liquid hot-spray membrane
- SikaCor® EG-5
- Sikaplan® WT-6200 synthetic membrane for sealing chemical containing tanks
- SikaGrout® cementitious grouts
- Sikadur®-42 SP epoxy grout
- Sika AnchorFix® chemical anchors
- Waterproofing & repair mortars
- Sika® Waterbars waterstops

**PROJECT PARTICIPANTS:**

**Owner:** HELLAS GOLD S.A.
**Main contractor:** AKTOR S.A.
**Sub-contractor for the Kokkinolaka reservoir waterproofing:** Emmanouil Kypraios





**SIKA SERVICES AG**
Tueffenwies 16
CH-8048 Zurich
Switzerland

**Contact**
Phone +41 58 436 40 40
www.sika.com

BUILDING TRUST