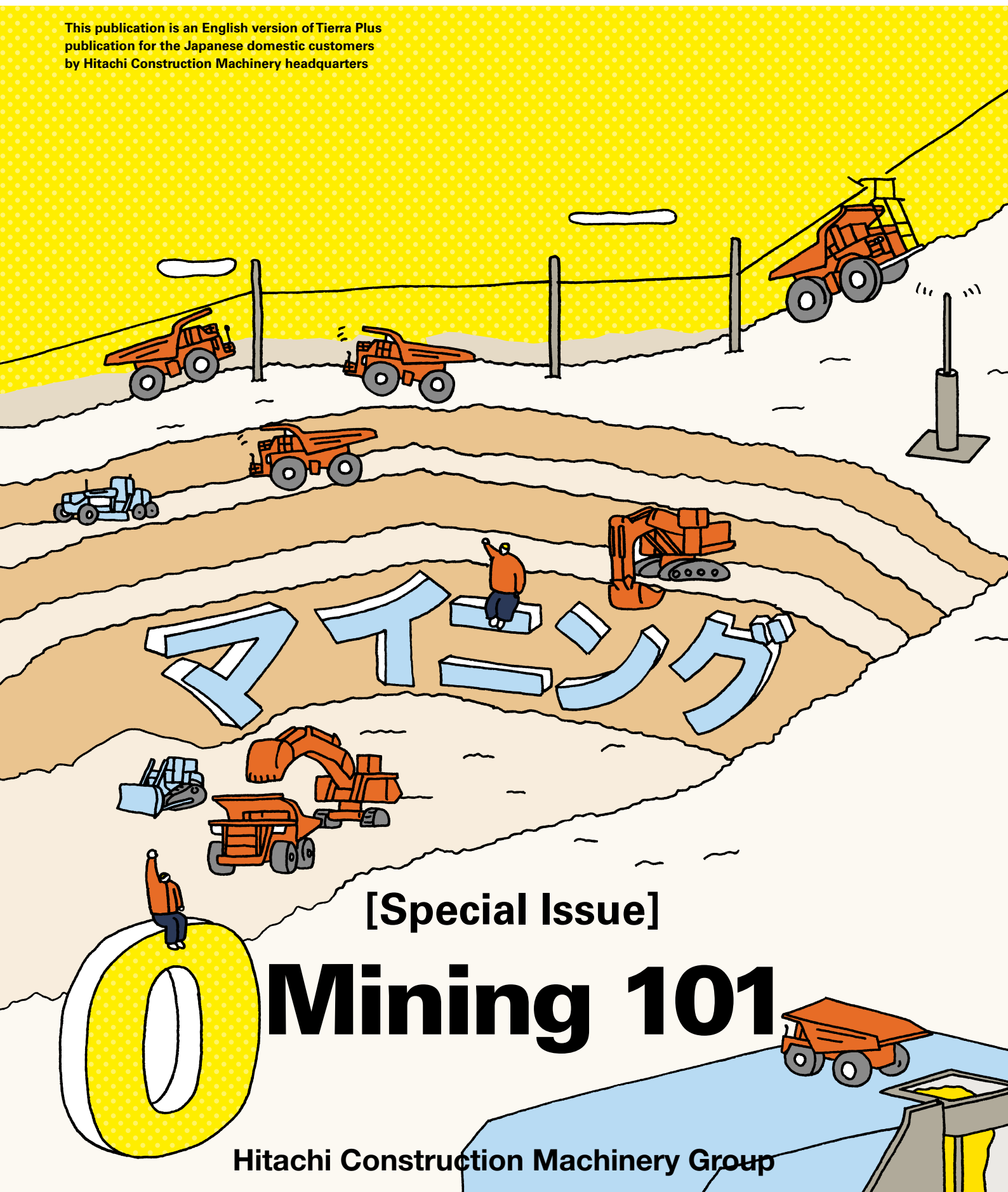


T I E R R A ^{plus}

Reliable solutions

Tierra Plus
Number 128

This publication is an English version of Tierra Plus publication for the Japanese domestic customers by Hitachi Construction Machinery headquarters



[Special Issue]

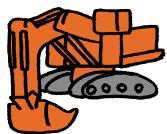
Mining 101

Hitachi Construction Machinery Group



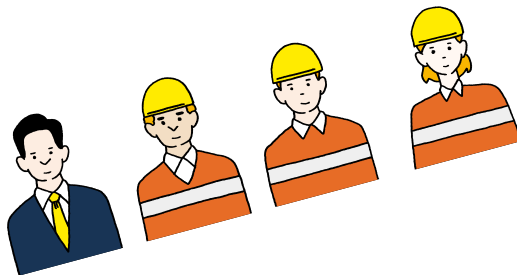
[Special Issue]

Mining 101



Cars, trains, electricity, electric appliances, coins... All these things that are essential to our lives are made of various mineral resources resting underneath the Earth's surface. This special issue reports on the current state of mining, including what kind of resources exist in the world and how mined minerals are used, as well as on the Hitachi Construction Machinery equipment used at mining sites.

Illustrations by Tokuhiro Kanoh



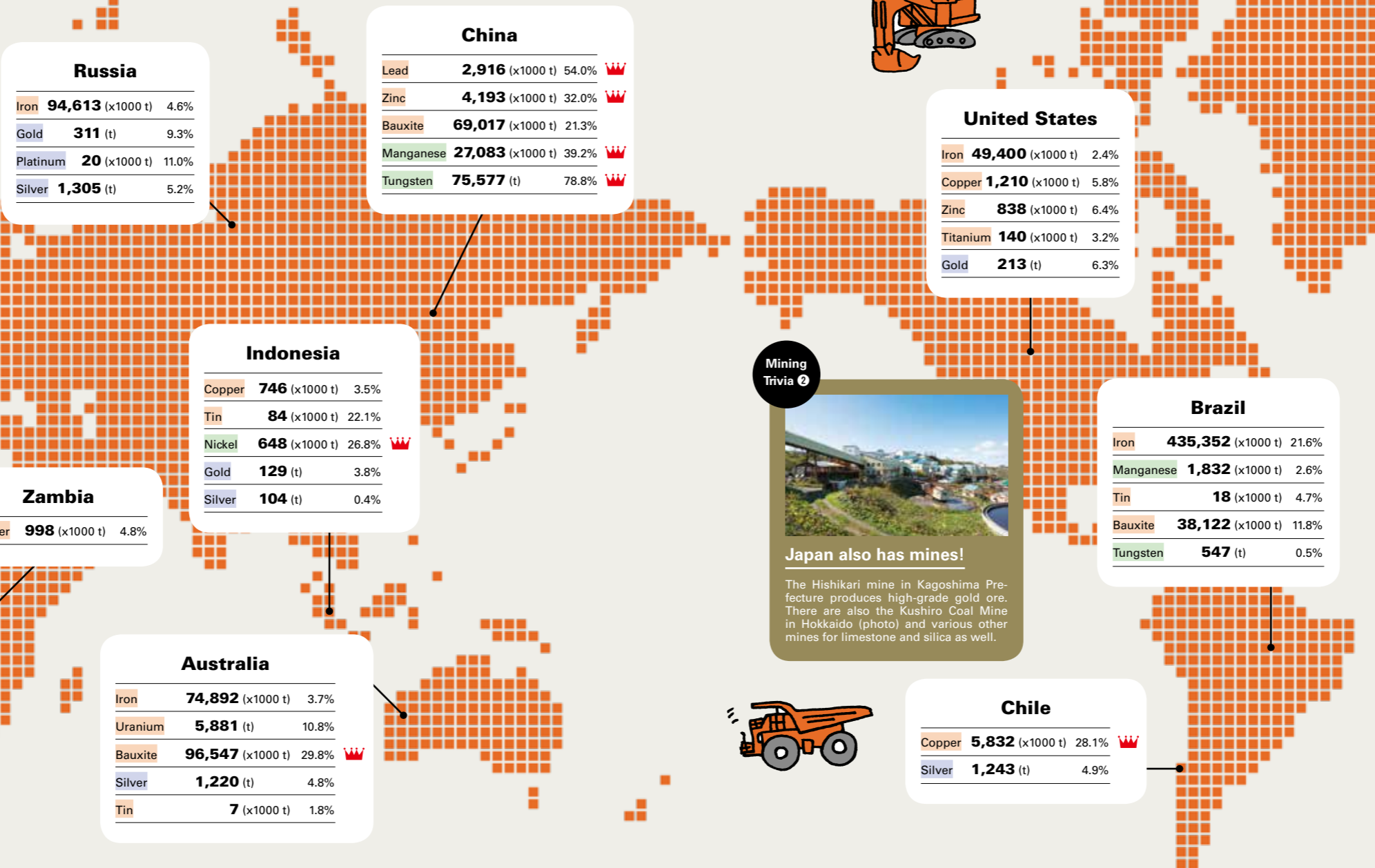
Basic Mining Knowledge in Pictures

Even if you have a general idea of what mining consists of, you've probably never seen the mining process or a mining site in person and there are many things you don't know about it. How and in what countries are minerals excavated and used in the manufacture of products? Let's start with some basic mining knowledge.

Text by Toshiaki Saito Editorial supervision: Japan Oil, Gas and Metals National Corporation (JOGMEC)

- marks rare metals.
- marks base metals.
- marks precious metals.
- marks the top global share.
- * Numbers for countries represent production amount (metallic content).
- * Only manganese is listed not as metallic content, but gross weight.
- * Percentages represent global share.
- * Reference: World Metal Statistics Yearbook 2019
- * World map is for illustrative purposes only.

The World's Primary Mining Countries



Mining Trivia 1

Where is the world's largest mine?

Chile's Escondida copper mine, which is larger than Tokyo's Imperial Palace, is considered the world's largest, but the Bingham Canyon (photo) copper mine located in the United States is of the same scale and over one kilometer deep.

Mining Trivia 2

Japan also has mines!

The Hishikari mine in Kagoshima Prefecture produces high-grade gold ore. There are also the Kushiro Coal Mine in Hokkaido (photo) and various other mines for limestone and silica as well.

What is ore?

Rock that has economic value because it contains a concentration of useful minerals is called "ore." Ore is a precious natural resource that the Earth has produced through volcanic activity and seismic shifts. Areas where ore is found are called "mineral deposits." The photograph shows iron ore.

How do the two mining methods differ?

• Surface Mining

In surface mining, ore is mined directly from the ground surface and is thus mostly used when deposits are near the surface. Designing a pit so that it attains more mined ore is a chance for mining engineers to show their skills.

• Underground Mining

This method creates a driftway so that ore can be mined from underground deposits. Underground mining is used when deposits are deep underground or when they are of narrow width. Depending on the shape of the deposit and the condition of the bedrock, there are various methods to prevent collapse of bedrock and allow efficient mining while ensuring safety and ventilation.

Is coal also ore?

Coal	25.1%
Oil	39.0%
LNG	23.4%
Nuclear power	1.4%
Hydroelectric	3.5%
Renewable energy, etc.	7.6%

Dependency on fossil fuels: approx. 87%

Coal is an aggregation of organic substances, consisting primarily of carbon, oxygen and hydrogen, and is not classified as ore. It currently provides about 25% of Japan's primary energy and can be considered a precious natural resource based on its stable supply and economic competitiveness.

Source: Agency for Natural Resources and Energy of the Ministry of Economy, Trade and Industry

Digging up Mineral Resources that Improve Human Lives

Simply put, a mine is a place where people excavate for "ore." As long as it's where people excavate for ore, it's called a mine, whether in the mountains or on flat land.

So what is this ore? The word ore describes rock that is economically worth digging up because it contains minerals rich in valuable metals that contribute to people's lives and industry. Gold ore, which contains gold, and iron ore, which contains iron, are well-known examples, but rock that contains silver, copper, tin, zinc, aluminum or rare metals like man-

ganese and nickel that have become much talked about in recent years is also called ore.

"Mining" is the work of digging up ore from the mineral deposits where it is found. In the case of copper, the actual copper to be mined makes up only about 0.3 to 1% of the overall ore. Excavated ore requires a process called "beneficiation," which separates useful minerals from the rest of the ore. The useful minerals collected through beneficiation are called "concentrates," and after they are transported to smelters by truck, rail, pipeline or boat, they undergo another process called "smelting." Through this process the minerals are

made into metals and can then finally be used as materials for various products we use in our daily lives, ranging from buildings and vehicles to smartphones, or for infrastructure such as power lines.

Broadly speaking, there are two methods of excavating ore: "surface mining" and "underground mining" (see images on the right). Hand drilling dependent on human labor used to be the norm, but in modern times, now that technology has developed sufficiently, large-scale mining using machinery has become commonplace. The progress of technology has had a large impact on the mining of mineral ore. In recent years technological development and pilot

projects have even begun for mining seafloor resources such as hydrothermal deposits.

When we look at the world's primary mining countries on the other hand, we see that each country has unique characteristics. For example, China produces a lot of lead and zinc, Chile produces copper, and Australia produces iron, bauxite and uranium. China is also characterized by its abundance of rare metals like manganese and tungsten. These days, African countries like Zambia and South Africa have been gaining attention as well. Zambia's economy in particular is supported by copper and Hitachi Construction Machinery is focusing on the

country by establishing local production, sales, and service bases, for example.

Today, the mining industry has been exploring sustainable development and uses. There are initiatives to minimize the negative influence on the surrounding environment and produce new value, such as by rehabilitating a mine through greening and stabilizing it after its closing or by using it as a location for tourism. Daily progress is being made to improve the efficiency and productivity of mining, as well as work safety, through the automation of machines that run in mining sites and the promotion of operation by centralized management systems.

Hitachi Construction Machinery advances global mining sites

Hitachi Construction Machinery manufactures ultra-large hydraulic excavators and dump trucks that operate at mining sites. In addition, Hitachi also supports mining operations in a range of ways, such as by providing systems and after-services.

Ultra-large Hydraulic Excavator

The World's Best-selling Ultra-large Hydraulic Excavator

EX8000-6

This giant hydraulic excavator extracts surface soil and minerals at mining sites. When the EX8000-6, one of the largest models of excavator, raises its bucket, it is as tall as a three-story building. There is also an electrically operated version that contributes to environmental protection and efficient mining operations. Ultra-Large Electric Hydraulic Excavators are able to work without producing exhaust gases or CO2 because they do not use combustion engines



We learned this from Hitachi Construction Machinery Vice President and Executive Officer President, Mining Group **Sonosuke Ishii**

Digging up and moving soil has been happening since humankind first appeared on the Earth. I believe that the construction machinery business which supports mining sites is a sustainable industry.

Hitachi Construction Machinery (HCM)'s cutting-edge technology is used at mining sites all over the world!

Responding to Special Mining sites Needs with "One Hitachi"

At mining sites, which require high productivity, long production stops due to machinery failure are unacceptable. Furthermore, the roads used for transporting minerals are unpaved and frequented by service vehicles as well. Advanced technology ensuring safety, durability, productivity and more is required of machinery operating in the harsh environment of a mine.

The biggest strength in Hitachi Construction Machinery's mining business is that all development and production are concentrated in Japan. The keyword is "One Hitachi." Sonosuke Ishii, president of Mining Group says the following.

"Our company marshals the comprehensive strength of the Hitachi Group

to develop and manufacture products for mining. By concentrating our hubs in Japan, we can collaborate with the research and development divisions of all the companies within the Hitachi Group and make maximum use of the various products and technologies that the Group possesses."

For example, the group jointly developed the technology featured in its dump trucks for transporting loads stably and safely (see page 9 about High-Performance Stability Control Technologies), applying automobile technology owned by Hitachi, Ltd. The dump trucks' Autonomous Haulage System (AHS), too, uses Hitachi, Ltd. technology, such as the railway traffic control system it has developed over many years.

"Different mining sites have different priorities: at some the performance

Rigid Dump Truck

A Dump Truck that Utilizes Combined Hitachi Group Technology

EH5000AC-3

Hitachi offers dump trucks that make the most out of the advantages of "One Hitachi" and fit a variety of customer sites. One topic in recent years has been the introduction of dump trucks featuring the Autonomous Haulage System (AHS, see next page) developed by marshalling the Hitachi Group's cutting-edge technology.



Dump Truck with Trolley-type Power Receiving System

This dump truck using electricity to climb slopes with a trolley system reduces fuel consumption, while also lowering CO2 output by reducing engine load.



Check out its performance in a video!



Expansion of Solution Business from Component Manufacture to Remanufacture

When it comes to responding to customers' needs, we would like to call attention to the Fleet Management System (FMS) that monitors the position and movement of multiple vehicles in real time to achieve their optimal allocation. This system contributes in various ways, such as by improving safety and productivity at mining sites, reducing running costs, and solving labor shortages.

At the same time, Hitachi Construction Machinery is also focused on its solution business, which revolves around the value chain. This solutions business is not limited to the sale of machinery, but responds to various customer needs,

such as by providing and remanufacturing parts, renting machinery, and providing cost management service. In 2016 the U.S.-based company H-E Parts, which provides service solutions for machinery and equipment, became part of Hitachi Construction Machinery Group, and in 2017 the Australian company Bradken, a major manufacturer of cast parts for mining machinery, did so as well. This created a structure for boosting HCM's solution business. "We used to be limited to the upstream processes of mining, but when H-E Parts and Bradken joined HCM, we became able to offer comprehensive services" (Ishii).

Hitachi Construction Machinery will continue to stay on top of new developments and extensively respond to its customers' needs.



solution1

Fleet Management System for Optimizing Operation

Fleet Management System (FMS)

At mining sites, rocks and minerals dug up by ultra-large hydraulic excavators are transported by multiple dump trucks. By monitoring this work in real time via GPS and radio transmissions, the FMS has made possible the efficient and safe dispatching of vehicles. This system is supplied by the Canadian subsidiary Wenco.



The FMS registers vehicle operations to improve production efficiency at the entire mining site and handles instructions and management for safe transport under continuously changing conditions.



solution2

Providing Optimal Services in Accordance with Customer Needs

Strengthening the Value Chain

Joining H-E Parts and Bradken into its corporate structure enabled Hitachi Construction Machinery to offer extensive service solutions for mining ranging from upstream to downstream. Utilizing the two companies' technologies and networks, HCM has begun creating synergies for strengthening its value chain.



H-E Parts is expanding a service business that creates added value for mining parts. It also owns a remanufacturing plant in the African nation of Zambia, a country HCM is focusing on.



Bradken specializes in casting machines and cast parts. Bradken's original technological expertise, business knowhow and network in the market for parts with a high frequency of exchange stand out in particular.

»» The Continuing Evolution of Mining

Taking Apart the Autonomous Haulage System for Dump Trucks!

Hitachi Construction Machinery is expanding its Fleet Management System (FMS), which monitors the status of various vehicles operating at a mine in real time and manages their allocation, to surface mining sites in countries. HCM's Autonomous Haulage System (AHS) is based on this FMS and has opened up a new world of driverless, autonomously operating dump trucks for mining sites. How will this technology, which embodies the capabilities of the Hitachi Group, change the future of the mining industry? We tried to find out based on what Tomohiko Yasuda, Assistant Vice-president of the Client Solution Business Division, told us.



We learned this from Hitachi Construction Machinery Assistant Vice-president of Client Solution Business Division and Assistant Vice-president of Mining Group **Tomohiko Yasuda**

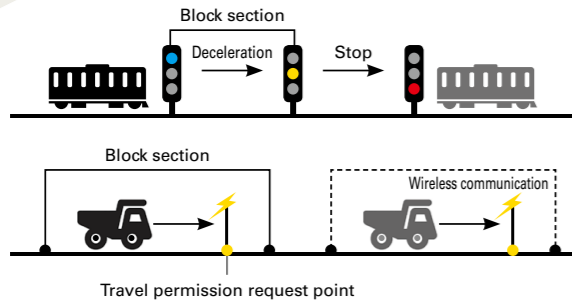
Nowadays mining companies are also investing with a long-term view and are trying to improve efficiency by adopting the latest technology. AHS is a perfect fit for these conditions.

AHS is transforming work at mining sites!

Is it true that AHS uses Hitachi's railway technology?

A Yes. AHS uses a system that lets trains run safely without bumping into each other.

AHS is a system that contributes to productivity, safety and cost optimization by autonomously steering dump trucks based on FMS signals. The path from the loading location for surface soil or ore to the unloading location is divided into several sections and when a dump truck has reached the beginning of one of these sections, it is told whether it can continue based on FMS signals. This framework is based on Hitachi Ltd. knowhow for dividing railway tracks into sections with multiple signaling mechanisms to let trains run safely.



Is complete automation possible?

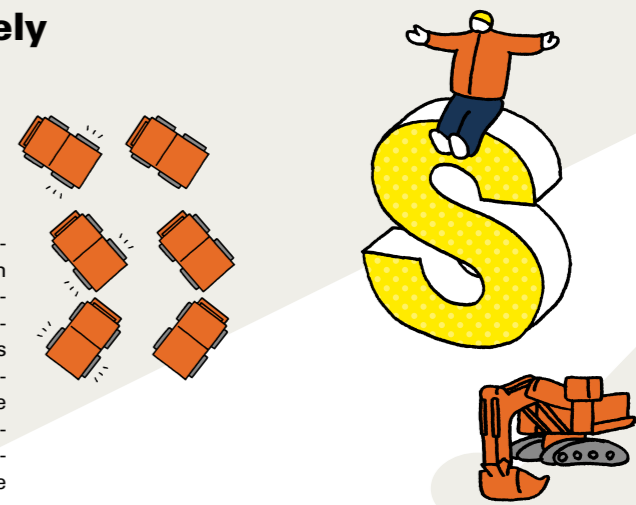
A In the future, "proceeding, stopping, turning" will likely all be done without drivers.

Dump trucks featuring AHS receive FMS signals that let the system automatically control departures, stops and steering operations to accomplish fully autonomous driving. Thanks to knowhow in railway traffic control system cultivated by Hitachi, Ltd., 50 or more dump trucks could probably be run autonomously. The trucks also have driver seats, so that they could be steered and driven by a human in the unlikely event of a problem.

Can the trucks drive safely without humans?

A They don't make mistakes or get tired like humans.

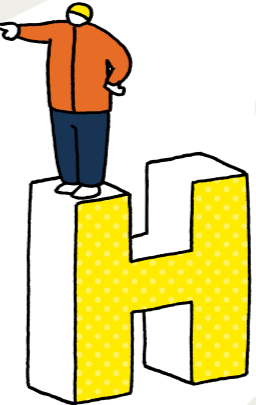
Human operators create the possibility of mistakes, reckless driving, accidents due to exhaustion or inattention, etc. AHS does not cause such problems based on human factors. Furthermore, because Hitachi Construction Machinery dump trucks are equipped with an advanced chassis stabilization control technology and run safely, with little chance of skidding, they are safe to operate without a driver. Features such as travel route recognition and obstacle detection additionally increase safety at mining sites.



Can this lower maintenance costs?

A Because it reduces the burden on vehicles and the roads they run on, it can reduce costs significantly.

AHS enables optimal driving that does not strain dump truck chassis or the roads that the trucks drive on, so damage to dump trucks based on extreme use and wear on road surfaces can be avoided, which lowers maintenance costs. Stable driving without excessive acceleration and deceleration or speeding also helps reduce fuel costs. Because AHS is expected to contribute to safety, its introduction results in ceaseless operation and productivity increases.



Can the introduction of AHS solve labor shortages?

A Autonomous driving is also effective in solving labor shortages.

Due to the notion that mines are far removed from cities and constitute a harsh work environment, young people have lost interest in mining in recent years and the mining industry is struggling to find sufficient workers. The automation of dump trucks contributes to solving such labor shortages. On the other hand it probably generates employment for engineers who handle the traffic control system. Since automation increases on-site safety, it is also effective in erasing the notion that the mining industry is dangerous.



For the future

Towards the Development of Sustainable Mining

Mining also has aspects that negatively impact the Earth. But mining companies don't simply dig through the ground and flatten mountains: they are undertaking a variety of initiatives such as protecting biodiversity and water resources and creating employment for people near mining sites, as well as improving their lives. The International Council on Mining and Metals (ICMM), which consists of 27 companies involved in mining and smelting, has also introduced ten principles for sustainable development, and is promoting collaboration with experts and helping the entire industry accomplish the targets set by the United Nations' Sustainable Development Goals (SDGs). Hitachi Construction Machinery, too, intends to further contribute to the development of society and the environment by mining resources efficiently through means such as the electrification and automation of ultra-large hydraulic excavators and dump trucks. In addition, HCM has bolstered its plant functions for remanufacturing parts for mining machinery and offers solutions for the effective use of old parts instead of discarding them. HCM thus plays a part in supporting mining's sustainability.

