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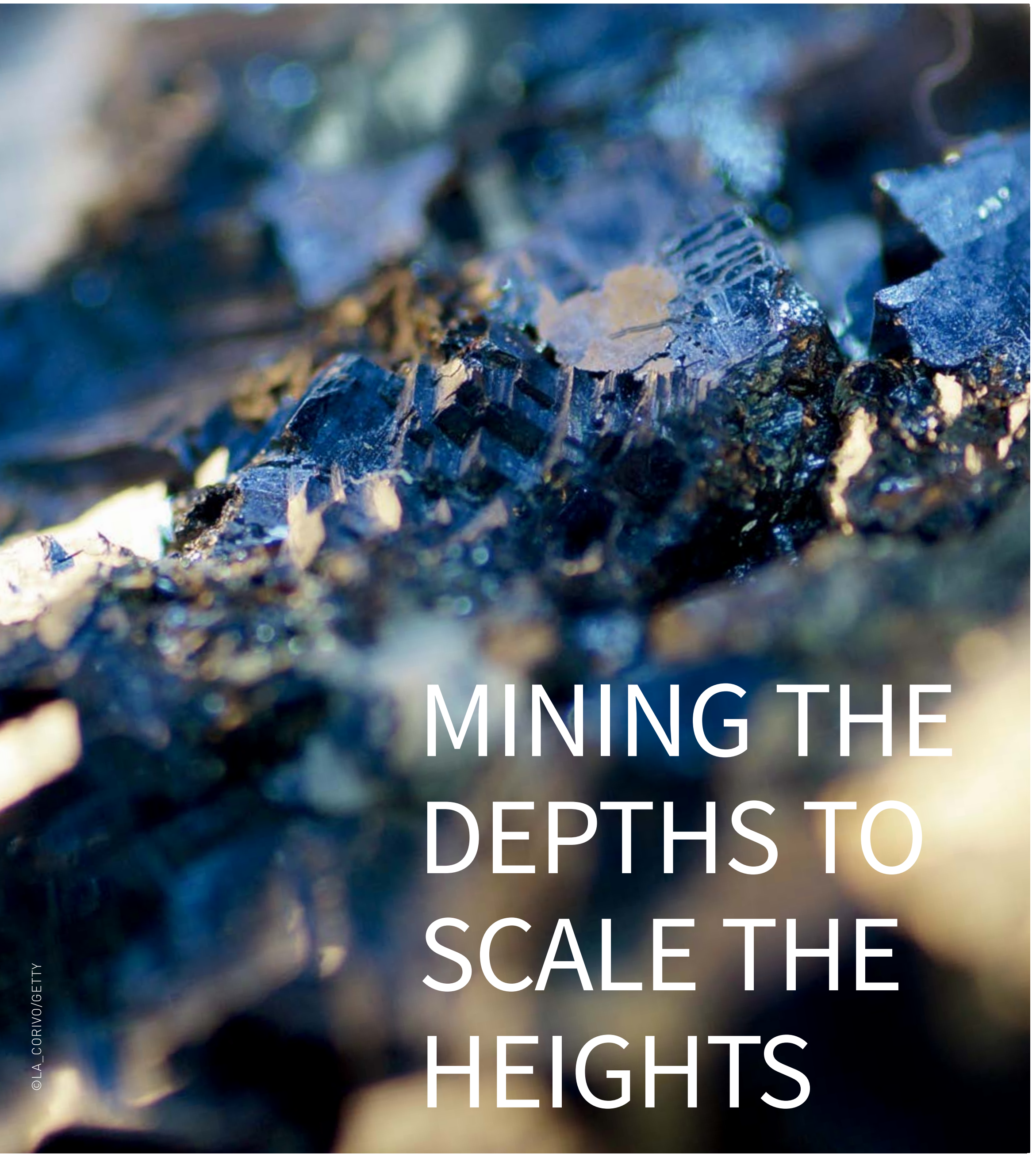

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MINING THE DEPTHS TO SCALE THE HEIGHTS

In line with a national goal to move from 'made in China' to 'created in China', Central South University (CSU) is committed to transforming the metal industry at every level. Mineral resources are the bedrock of manufacturing. On the strength of 100 years of mineral studies performed by Hunan Industrial College, CSU has built the world's most comprehensive academic cluster around nonferrous metals, ranging from geology and mining, to metallurgy, materials science and machinery engineering.

Aimed at making production more efficient, energy-saving, and environmentally friendly, new technologies, instruments, and materials developed at CSU are used in many major engineering projects in China, advancing the entire industry.

GEOLOGY

Access to the Earth's rich mineral resources is limited by prospecting technologies. China's deep Earth exploration plan develops equipment and methods to explore at two to five kilometres underground. A CSU invention has improved the accuracy of mineral prospecting, helping the country's goals for resource security.

Using the electromagnetic field, a process developed by He Jishan, a renowned geophysicist at CSU and member of the Chinese Academy of Engineering (CAE), is a major improvement on the geophysical survey method used extensively now, enabling greater depth, resolution and prospecting signal strength.

Electromagnetic techniques have long been recognized as effective prospecting approaches, but an electromagnetic wave equation measuring underground transmission has proved too complex, preventing the design of a high-precision prospecting equipment.

An alternative wide-field electromagnetic method, proposed by He, offers a precise solution. Using both a grounded electric dipole and an ungrounded magnetic loop as field sources, it can be used in the far field, the transition zone, and part of the near field, He explains.

Electromagnetic prospecting instruments designed by He's team are widely used in mineral exploration nationwide, bringing efficiency, cost savings, and time-saving benefits. They are particularly valuable in western China's mountainous areas, where mineral resources are hidden very deeply underground, making traditional geophysical prospecting methods ineffective.

One of He's instruments, with full-frequency oscillation, can quickly and accurately discriminate between metals and non-metals based on spectrum characteristics, and can overcome electromagnetic interference caused by activity at nearby productive mines.

The portable unit can be used for fast, large-area surveys. Now being used in more than 200 mines or oilfields, it has helped locate ore with potential value in excess of 1,500 billion RMB.

MINING

Excessive mining activities are depleting superficial deposits of ore, promoting sustainable development of the industry to the top of China's agenda. CSU's mining researchers are devoted to finding safe and efficient mining technologies that reduce environmental damage and enhance intelligent extraction.

Complex conditions and a lack of superficial metal deposits have led to the exploitation of hazardous mines in China, including soft or broken ore bodies and highly stressed ore pillars. With a focus on environmental impact and production safety, CSU researchers have proposed theories and methods of continuous mining, improving safety and efficiency.

Among their discoveries is technology for large-diameter deep-hole blasting in soft and broken ore bodies. They have also developed a micro-seismic monitoring and warning system in case of rock structural failure. As well as significantly reducing mining accidents, these technologies are applicable in disaster prevention for hydraulic/hydro-power projects, civil engineering, tunnel engineering and other construction projects.

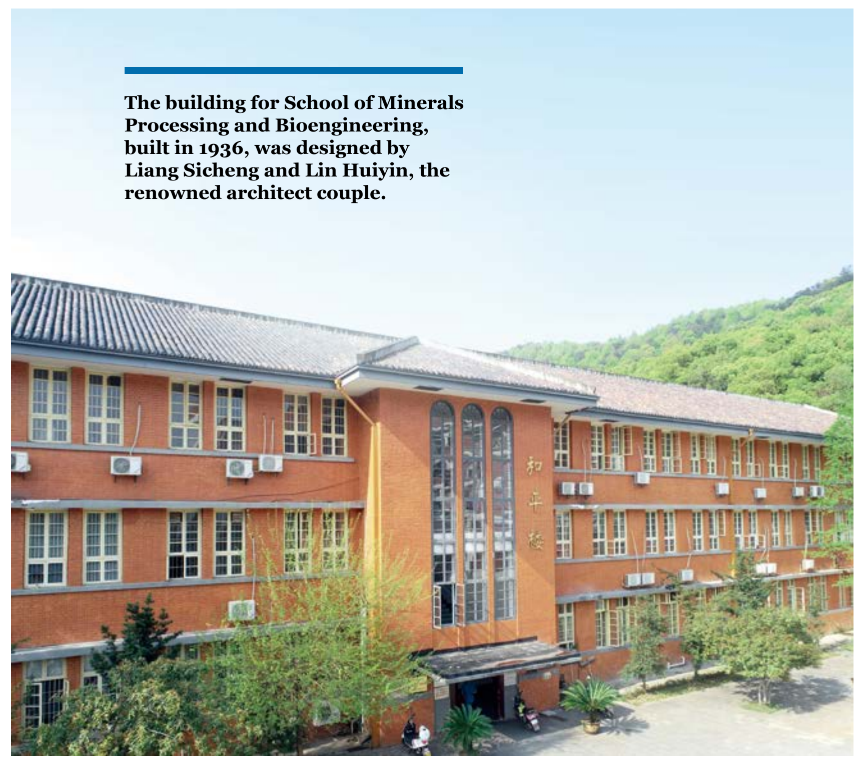
Efforts to curb environmental damage complement improving mining safety. As the world's largest producer of phosphates and phosphorous chemical products, China is subject to significant pollution.

Great demand has led to widespread exploitation using old and unsophisticated mining methods, which lead to mountain collapses and ground subsidence. Finding technology that limits waste and damage is at the centre of efforts at CSU.

Mining researchers have found a way to make use of phosphorous manufacturing waste by turning it into self-gelling filling materials. Their innovation has led to the world's first system to process ultra-fine, corrosive phosphorous slags into filling materials, and the first waste-free mines using processed phosphorous wastes for filling.

CSU's non-waste mining technologies bring an environmental gain, while preventing landslides and other disasters caused by exploitation. They have also improved efficiency of metal and chemical mining and the use of resources, which brings major economic gains.

The latest breakthroughs have come from developing software and equipment for intelligent mining, contributing to the important move towards unmanned mining.



The building for School of Minerals Processing and Bioengineering, built in 1936, was designed by Liang Sicheng and Lin Huiyin, the renowned architect couple.

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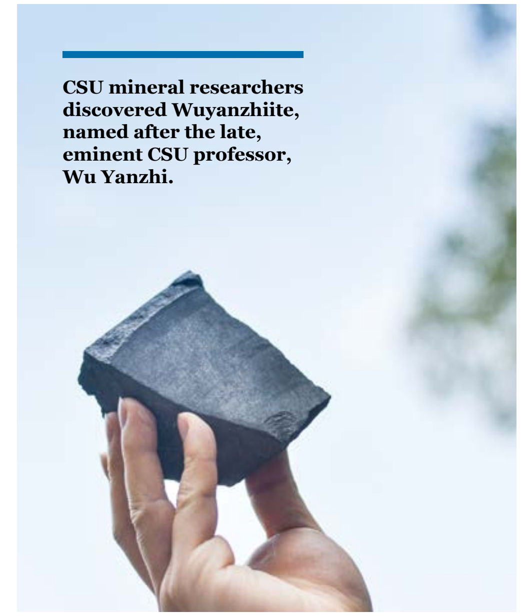

CSU mineral researchers discovered Wuyanzhiite, named after the late, eminent CSU professor, Wu Yanzhi.

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MINERAL PROCESSING

After minerals are located and extracted, commercially valuable substances must be separated from their ores, a process known as ore dressing. Often, a large proportion of ore turns out to be waste, so improving the efficiency of ore dressing is essential for effective and sustainable use of resources.

CSU is a leader in ore dressing technologies. Its mineral engineering expert, Wang Dianzuo, a member of CAE, and the Chinese Academy of Sciences (CAS), as well as a foreign member of the US National Academy of Engineering, is a pioneer of the flotation technique, a common processing approach that separates well-ground minerals from the slurry by using chemicals to make them water-repellent. Wang proposed the theory of molecular design, which optimizes reagent combinations for more efficient flotation separation.

CSU researchers have made breakthroughs based on Wang's work. By analyzing the solubility of minerals and reagents, and clarifying how to keep chemical equilibrium of the dissociation solution, they developed a chemical theory for adjusting the mineral flotation solution. With a technique developed for separating aluminium-bearing minerals, such as diaspores and aluminosilicates, they established the world's first flotation plant for efficient processing of low-grade diasporic bauxite, having significantly extended China's usable bauxite reserves.

Another challenge in mineral processing is the flotation separation of calcium-bearing minerals, such as tungsten, phosphate, and fluorite ores — strategic mineral resources which underpin the development of several emerging industries. To increase selectivity, CSU researchers have developed technology for flotation collector assembly, integrating mineral processing and waste utilization. Their work has led to a significant improvement in efficient treatment of those minerals.

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METALLURGY

Metallurgical engineering, a process that transforms metals into useful products, is integral to the nonferrous industry. CSU researchers lead the field, especially in the refining of tungsten and aluminium.

The electrolytic production of aluminium, a widely used approach, is enormously energy intensive. By innovating the electrolytic technology and building a large model of an aluminium cell, CSU researchers have developed a control system that achieves low-voltage, efficient automation of the electrolytic process — in which the energy consumption to produce aluminium was the lowest recorded. Their work has been applied in more than 50 aluminium factories around the world, and more than 60% of China's aluminium production.

Tungsten, a tough and heat-resistant rare metal, is an essential resource in many key industries. However, its recovery from scheelite ores, which usually have high concentration of molybdenum and other wastes, presents a challenge, as alkali decomposition of scheelite is difficult. CSU researchers have developed a series of technologies, including a caustic process for tungsten extraction, high-concentration ion exchange for waste removal, and autoregulation of hard metal structures, enabling efficient tungsten recovery. These technologies have helped extend China's tungsten reserves from around five years to more than 25 years. The metals it creates are used in high-performance products that serve China's aviation and aerospace industries. More importantly, these technologies have reduced wastewater discharge by 80% per year.

A technology using a mixture of sulfuric and phosphoric acids for the extraction of tungsten has enabled high-efficiency recovery under normal pressure. It creatively uses solid waste as filling materials in construction and achieves water recycling.

CSU scientists also focus on the recycling of waste from metallurgical processes. By screening and isolating heavy metal-resistant bacteria, CSU researchers have invented a microorganism-based reagent for deep cleaning of wastewater containing heavy metals. Using this technique, treated water quality has significantly improved, compared with using the traditional the lime-based method.

Moreover, heavy metals from wastewater, such as zinc and copper, can be recycled and reused, and the wastewater from metallurgical process can be recycled with a reclamation rate over 90%. The technology has been used in more than 100 enterprises in China, including Zhuzhou Smelter Group, the country's largest base for zinc production.

CSU's inventions also include treatment of solid waste containing arsenic, recycling of electronic wastes, and separation and recovery of multiple valuable metals from acid waste. These inventions could lead to a 'green' revolution of the metallurgical industry.

MATERIALS SCIENCE

Tungsten materials, with their use in aerospace, national defence, new energy and microelectronics, are vital for the economy and defence. In China, rapid high-tech development has increased demand for tungsten materials. When it comes to strength in tungsten refining technologies, CSU researchers are peerless. They lead in the deep-processing of tungsten composites.

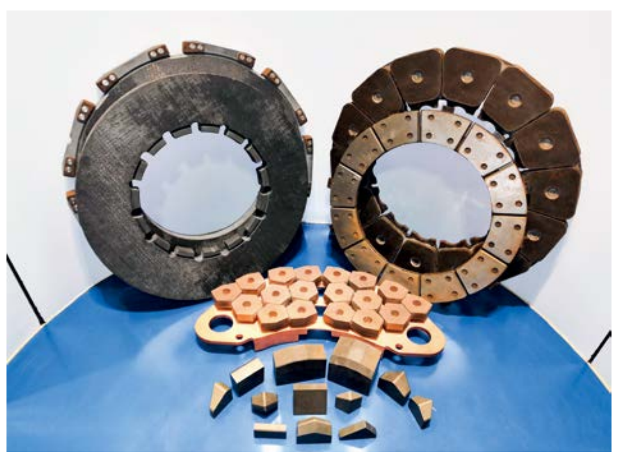
The traditional approach for preparing tungsten materials has limited their size, structure and performance. Using novel solution chemistry methods, CSU researchers have developed ultra-fine, nano tungsten composite powders of only 30-50nm, which make quality raw materials for high-performance products.

They also proposed optimal densification processes for making bulk tungsten alloys with nano- or micro-metre structures, and invented cemented carbides composed of tungsten carbide, which have functionally graded structures. The new tungsten alloys and cemented carbides developed at CSU are tough and robust, ready for use in high-value and sophisticated engineering projects.

From high-speed trains to aircrafts, lightweight, strong, and heat resistant carbon-carbon composites are a major brake material. CSU researchers' unique technology to produce high-performance carbon-carbon composites made China one of the four countries capable of producing carbon-carbon aerospace brake materials. They have also built pilot production platforms and a company for large-scale production of such materials, used in the brake system of Boeing 757 aircrafts and China's new-generation aircrafts.

Moreover, various powder metallurgical friction materials developed at CSU were widely used in China's space shuttles, rocket engines, heavy vehicles and automobiles.

In the processing of light, strong magnesium alloys, CSU is also taking a lead. Researchers have developed novel magnesium alloys with superior strength and heat resistance, which have been made into large components for use in aerospace and aviation. A world-leading production line with a total investment exceeding 8 billion RMB is now under way.



CSU scientists forged China's largest high-strength alloy ring for use in new-generation rockets.

MECHANICAL ENGINEERING

With China's moon exploration and space station ambitions soaring, the building of heavy-lift launch vehicles is to be a national priority.

These vehicles, along with rocket and aircraft parts, are very large, and have high performance demands. To enhance their service performance, mechanical engineering researchers at CSU are updating alloy composition design, forming techniques and processes to manufacture high-quality, integral large parts.

For plans to increase rocket loads from 20 tonnes to 100 tonnes, rocket diameter will double from 5m to 10m.

To prepare parts for such an increase, a CSU team, led by Zhong Jue, a CAE member, has forged a 9.5m-diameter ring of high-strength aluminium alloy, China's largest. Forged in one piece, the alloy ring's uniformity ensures consistent properties and high performance for use in next-generation heavy-lift rockets. An earlier version of the technology to ensure uniformity and properties of large parts yielded China's largest alloy ingot.

The launch vehicle's propellant tank must also be made bigger, while remaining light and thin, presenting a manufacturing challenge. Zhong's team has studied mechanisms for precise formation, and developed an ultrasound-assisted technique for casting large, high-strength, high-purity aluminium alloy ingot. Using an updated creep-age forming (CAF) technique that integrates property and form control, they have also developed a super-large thin-walled curved plate that is integrally stiffened, as well as a rocket tank scalloped segment plate, the world's biggest.

These large-scale parts can also be used in aircraft, benefiting China's aeronautic development.

CONTROL SCIENCE

Sustainable development of the nonferrous industry demands energy conservation and waste reduction. CSU's control science researchers have developed intelligent integrated optimization and control technology for green production of nonferrous materials.

One example of their work is controlling the metallurgical process of complex nonferrous metals. In zinc electrolysis, a key extraction approach, they were the first in China to model a time-sharing power supply to optimize electricity use. The control system will automatically reduce electricity use when the power grid is under a heavy workload, and increase use when demand is low. It has significantly reduced energy use and cost, while ensuring stable and efficient electrolysis for zinc production. The technology is also used to optimize copper smelting production process, having improved the automation of copper flash smelting process to an advanced level internationally.

In the processing of large aluminium alloy components for aerospace use, CSU's intelligent control techniques help stabilize the quenching temperature and improve the forging accuracy. Their high-efficiency and energy-saving control technology is also used in large aluminium electrolysis cells of different capacities, yielding significant emission reduction and keeping energy consumption lower than the global standard levels.

CSU researchers have also invented mineral processing monitoring technology, enabling online detection of metal grade in the beneficiation process. Applied in the flotation of sulphur, gold and other metals, the technology has improved the efficiency of recovery rate and metal concentration levels.

In research on control theories, CSU researchers proposed a free-weighting matrix method for robust stability analysis, and revealed how the delays are related to system stability and performance.

The method is widely used worldwide, becoming one of the most effective ways for robust control of delay systems. ■

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