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The Massive Prize Luring Miners to the Stars

The asteroid Vesta, viewed from NASA's Dawn spacecraft. Photo by [NASA/JPL-Caltech/UCLA/MPS/DLR/IDA](#)

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March 8, 2018

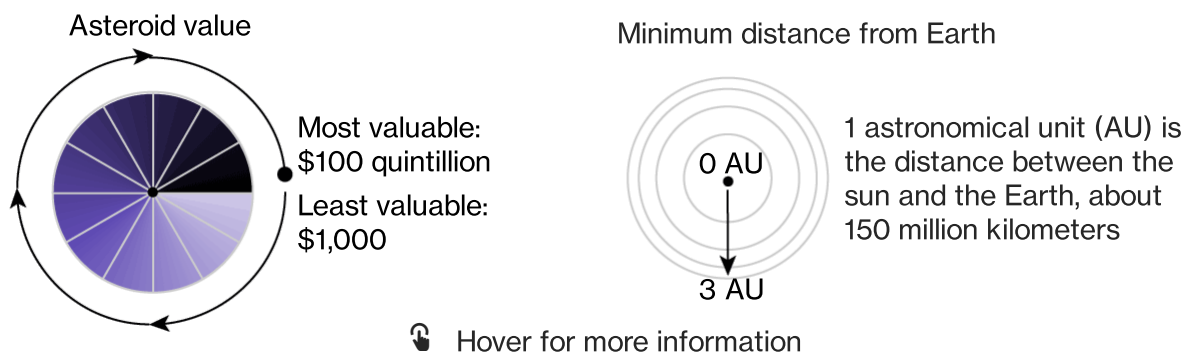
Sending a spacecraft to the far reaches of our solar system to mine asteroids might seem like an improbable ambition best left to science fiction. But it's inching closer to reality. A NASA mission is underway to test the feasibility on a nearby asteroid, and a niche group of companies is ramping up to claim a piece of the pie.

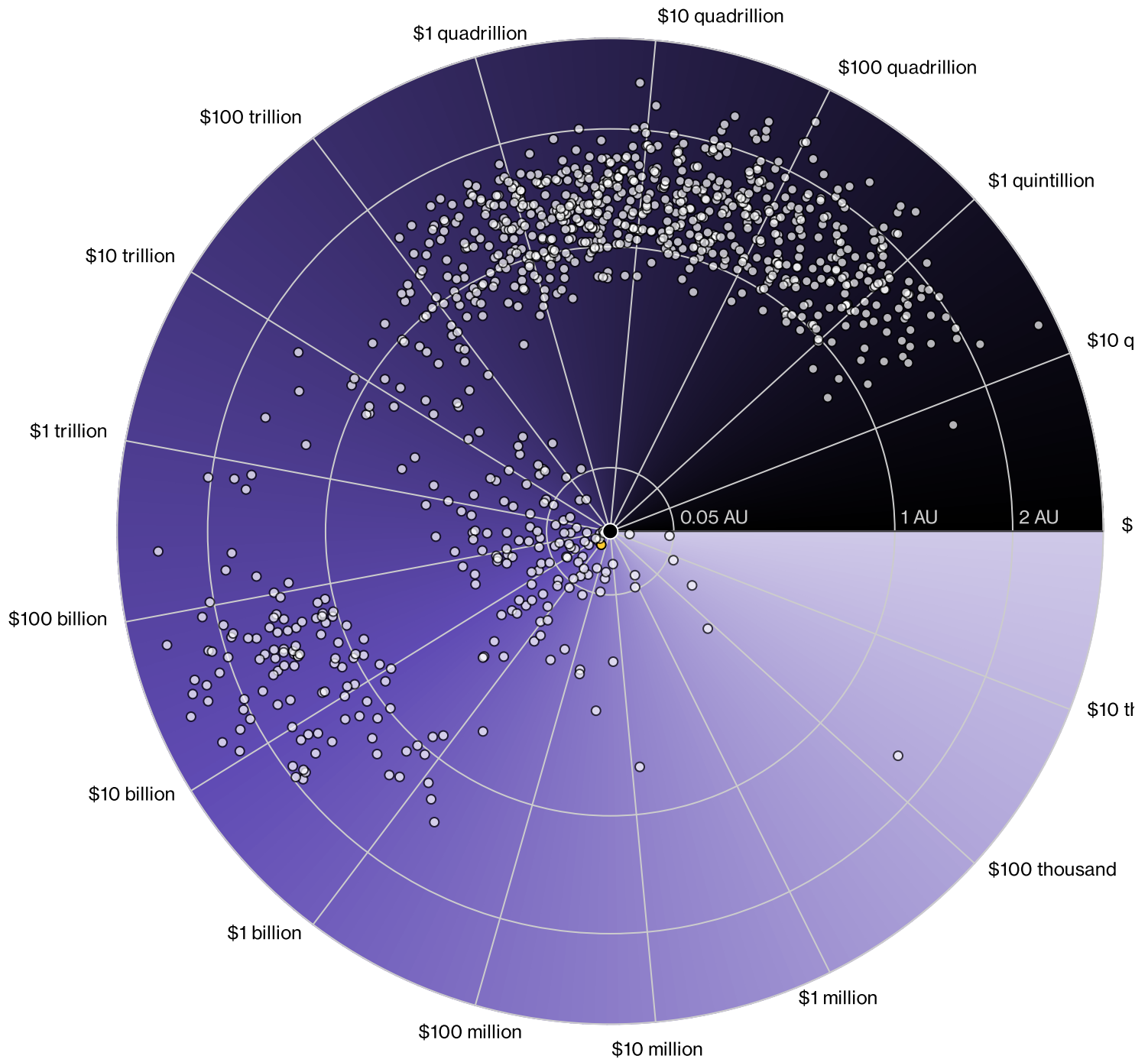
Industry barons see a future in finding and harnessing water on asteroids for rocket fuel, which will allow astronauts and spacecrafts to stay in orbit for longer periods. Investors, including Richard Branson, China's Tencent Holdings and the nation of Luxembourg, see a longer-term solution to replenishing materials such as iron and nickel as Earth's natural resources are depleted.

Millions of asteroids roam our solar system. Most are thought unsuitable for mining, either because they're too small, too inaccessible to Earth or because the materials that make up the asteroid have little value. But we know of almost 1,000 asteroids that show potential. Timing is everything, though. The varied orbits of these asteroids mean that many are nearby only once every several years.

The estimated potential value of some of these asteroids—assuming you could completely mine them, and assuming current market valuations—is so substantial as to be barely comprehensible. The most valuable known asteroid is estimated to be worth \$15 quintillion, according to [Asterank](#), a database owned by Planetary Resources, a company that aims to mine asteroids. That represents the world's total gross domestic product (about [\\$80 trillion](#)) 192,283 times over.

Most Valuable Asteroids Are Far From Earth





Note: Asteroids shown have a valuation of at least \$1,000 and a minimum orbit intersection distance of 3 AU or less. Valuations are displayed on a log base ten scale, while minimum orbit intersection distance is shown on a square root scale. Source: [Asterank](#)

There's a lot we still don't know about these asteroids, so their estimated values should be taken with a grain of salt. Scientists who study asteroids group them into different categories based on certain shared criteria, including size and shape, and estimate their composition based on samples of similar meteorites. But within each asteroid category, the makeup of individual asteroids will vary, affecting its value to would-be miners.

What we do know about the asteroids, however, gives researchers and companies a good ballpark as more ambitious exploration gets underway.

Osiris-Rex, a U.S. National Aeronautics and Space Administration spacecraft, is on its way to a near-Earth asteroid to check out whether it will be viable for extracting water and minerals.

It's expected to reach the asteroid, Bennu, in December, becoming the first U.S. mission to retrieve a sample of an asteroid and return it to Earth to be studied, said Dante Lauretta, a University of Arizona professor, who is working in conjunction with NASA as he oversees the mission.

“We’re interested in finding sources of water for furthering exploration,” Lauretta said in an interview. “Anytime you’re involved in space flight, it’s a risky business. We have a lot of technologies to overcome the challenges of navigating a spacecraft around the asteroid.”



Technicians test the Osiris-Rex spacecraft at NASA's Kennedy Space Center in Florida on July 13, 2016. Photo by [NASA/Kim Shiflett](#)

Bennu comes very close to Earth every six years and scientists estimate that asteroids of its type are made of about 10 percent iron and nickel. Asterank values Bennu at \$670 million, though Laretta says too little is known about Bennu's composition to understand its potential value.

During its time at Bennu, the spacecraft will analyze the asteroid's shape and chemistry, sample its surface materials and collect data on its orbit so scientists can determine the likelihood of it crashing into Earth in the future. The spacecraft is scheduled to return to Earth in 2023, he said.

"The next iron age is going to be in space as people use technology to build communities," said Chris Lewicki, president of Planetary Resources, one of the first movers on asteroid mining. The company aims to launch a mission by 2020 to identify water resources in asteroids.

Mining will take longer, but he says that shouldn't surprise anyone. It's "not unusual" for mining projects on Earth to take upwards of 15 years before they're productive, he said.

Lewicki expects the space economy could morph into at least a \$1 trillion market as mining picks up. "It's uncharted territory."

Osiris-Rex's Mission to Bring Asteroid Samples Back to Earth

Osiris-Rex launched from Cape Canaveral in Florida in 2016. It has traveled over 1.3 billion kilometers since then, orbiting the sun for a year and hurtling past Earth to change course toward Bennu.

Two solar panels generate between 1,266 and 3,000 watts of power for the spacecraft, depending on its distance from the sun.

The high gain antenna, which is covered in Mylar, sends information between the spacecraft and Earth.

In August, Osiris-Rex will capture its first images of Bennu and begin its 2-million-kilometer approach, arriving in December. It will spend more than a year orbiting the asteroid to sun and photograph it.

Then, in July 2020, Osiris-Rex will descend to Bennu's surface and retrieve up to three samples. After nearly four years in space, Osiris-Rex will spend mere seconds extracting material from surface of the asteroid.

Detail

When Osiris-Rex is in place above Bennu's surface, it will extend an articulated arm with a device to collect samples, the Touch-and-Go Sample Acquisition Mechanism (TAGSAM).

TAGSAM will touch the surface of Bennu for about five seconds while releasing a burst of nitrogen gas. This gas will stir up some surface material, called regolith.

Nitrogen cartridges

TAGSAM can collect between 60 and 150 grams of regolith. Finally, TAGSAM's arm will put the sample head into a capsule that will stay sealed until it is opened by scientists back on Earth.

Sampler head

Regolith

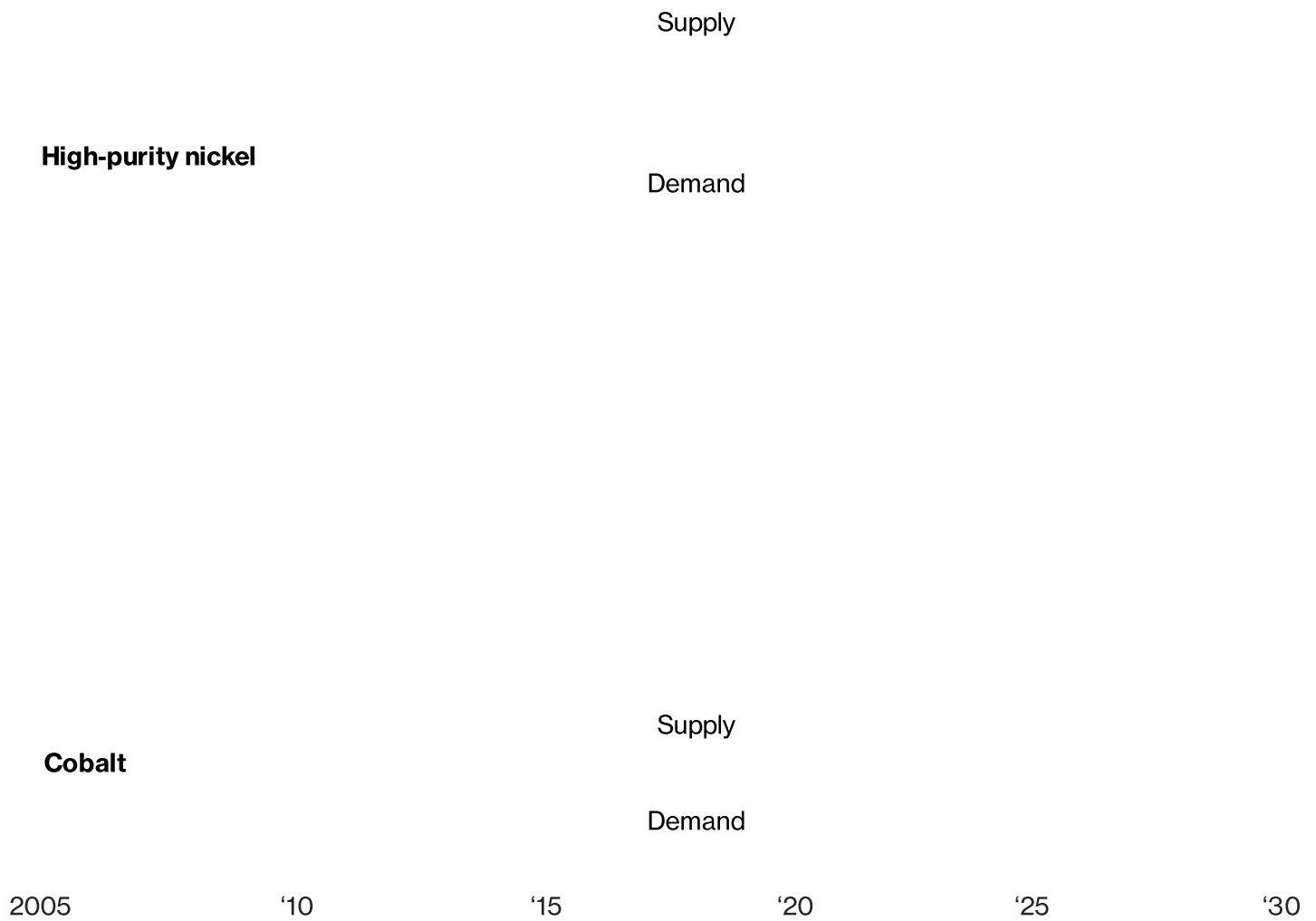
Osiris-Rex will begin its return journey back to Earth in March 2021. When it nears Earth,

Note: Illustration is not to scale.
Sources: Osiris-Rex mission, NASA

The U.S. isn't the only country eyeing intergalactic mining. Tiny Luxembourg wants to become the space hub of the European Union. It passed a law in 2017 that gives companies the rights to whatever they extract from asteroids. The U.S. has similar rules in its 2015 Commercial Space Launch Competitiveness Act. Setting early ground rules was the Outer Space Treaty of 1967, administered by the UN's Vienna-based Office for Outer Space Affairs. It keeps space free of all national sovereignty or ownership claims—plus nuclear weapons—and restricts the use of the moon and other space bodies to peaceful purposes. It was signed by about 60 countries, including the U.S.

Asteroid mining is seen as a potential solution for resource depletion on Earth. Over the next decade, demand for nickel and cobalt is projected to spike and outpace available supply as the production of electric-vehicle batteries, which use those metals, surges.

Metals Found in Some Asteroids Are in High Demand on Earth



Note: Projected demand beyond 2016 includes projected demand for electric-vehicle battery materials and constant demand for metals used for other purposes.
Source: Bloomberg New Energy Finance

As mining asteroids becomes more commercially viable, laws governing accidents or environmental mishaps may have to play catch-up. And if asteroid mining does take off

in certain metals, the additional supply could push down prices on Earth. “This represents a considerable risk for producers,” according to Diego Oliva-Velez, commodities and mining analyst at BMI Research.

With friendly regulations in place, space entrepreneurs are on the move. Companies led by Elon Musk, Jeff Bezos and Branson are leading the drive to expand travel, a critical step in building that community. They are focused on flights, via SpaceX, Blue Origin LLC and Virgin Galactic, to take people and cargo into orbit. NASA also plans to launch a mission in 2022 to Psyche, a metal asteroid that orbits the sun between Mars and Jupiter and is thought to be the nickel-iron core of an early planet.

Although the excitement is feverish, the industry faces significant challenges. Financing is “the piece of the puzzle that hasn’t fallen into place yet,” Laurretta said. “Who will invest serious money to make this happen? We’ve solved the technology problems. How do we spur investment in this industry?”



An Atlas V rocket carrying Osiris-Rex launches from Cape Canaveral in Florida, Sept. 8, 2016. Photo by [NASA/Sandy Joseph and Tim Terry](#)

Institutional investors are not exactly falling over each other to contribute cash. Yet there are those who relish the first mover advantage. Planetary Resources counts Tencent Holdings, founded by Chinese billionaire Ma Huateng, as a key investor, along with Branson and the Luxembourg government. Tencent also invests in Moon Express, a startup that aims to put drones on the lunar body. Another key player, Deep Space Industries, is pursuing plans to mine asteroids.

Deep Space Industries expects to “spend tens of millions of dollars before seeing first revenue from our asteroid mining operations,” Peter Stibrany, chief business developer and strategist, said in an email. Within seven to 10 years, Deep Space Industries plans to sell propellant, based either on water or on other fuels derived from asteroid materials.

As extraterrestrial travel expands, cosmic applications will be needed to service the industry, which is expected to bring metals back to Earth in the 2030s. Made In Space, a Mountain View, California-based company, plans to use 3-D printing to manufacture metal parts in space to support those who live and work there. The company also plans to start a recycling technology system in the next year that will reuse plastic in orbit. It uses a 3-D printer about the size of a microwave oven on the International Space Station to make plastic parts for antennas, radars and satellites.

“In the early stages, space mining will primarily be driven by its role in supporting future space exploration,” according to a 2017 BMI analysis. “In the longer term, we view the increasing depletion of reserves as a more likely catalyst for miners to engage in space mining for resource beneficiation, despite the high costs.”

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