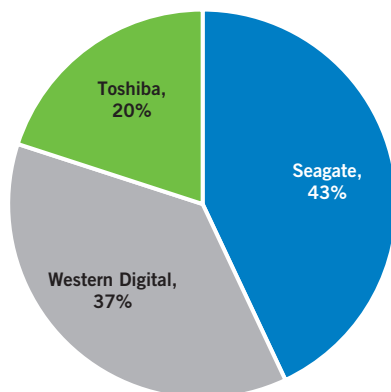


MARKET SPOTLIGHT

How will ruthenium fare in the fight for HDD supremacy?

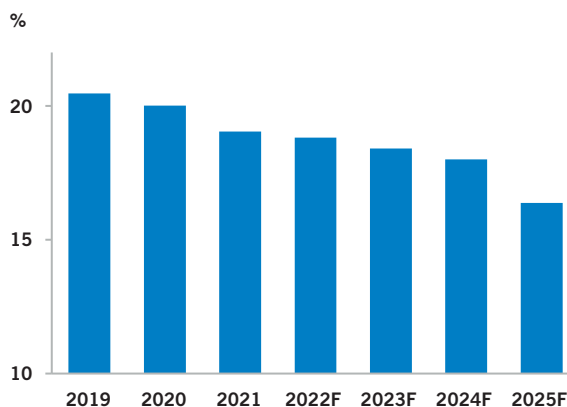
The hard disk drive (HDD) market is an important demand sector for ruthenium, accounting for around 20% of total electrical demand for ruthenium in the last year (~65 koz). However, while the need for high-capacity data storage is rising, the impact on ruthenium demand is not linear. The shift to remote working and distance learning has accelerated the move to cloud-based services, resulting in rapid growth in mass capacity storage requirements. In addition, Internet of Things (IoT) technology is starting to scale up, and growing interest in Industry 4.0, considered the fourth industrial revolution, is expected to be the impetus for storage capacity growth in the manufacturing space. Seagate, which has a 43% share of the market, shipped 152.3 exabytes of HDD storage in Q4 FY'21 (+30% year-on-year). During Q2 FY'21, mass capacity accounted for 65% of Seagate's total HDD revenue, up from a 46% share two years ago.

HDD market share by manufacturer



Source: SFA (Oxford), Coughlin Associates

Ru: HDDs as a % of electrical demand



Source: SFA (Oxford)

Existing PMR technology for HDDs is starting to reach its capacity limit. The ruthenium-containing technology known as perpendicular magnetic recording (PMR) has reached a limit in terms of decreasing bit area, so a transition to energy-assisted technologies (HAMR and MAMR), which support smaller bit areas, is underway. The three global HDD manufacturers, Seagate, Toshiba and Western Digital, are taking slightly different approaches, with varying outcomes for ruthenium demand. Toshiba and Western Digital's favoured HDD technology, MAMR, will continue to use ruthenium, but Seagate, the champion of HAMR technology, will eventually no longer require ruthenium at all (though will use more platinum).

However, ruthenium-based HDD technology remains competitive over the next 4-5 years as the migration to HAMR technology (no Ru) is quite slow, and the limits to existing materials and technology are stretched even further. Western Digital expected PMR to reach its limit for areal density increase after it reached its 16 TB drive but was able to launch a 20 TB drive last year without using MAMR at all. Disk-makers have proved their ability to grow disk capacity with only moderate investment in new hardware while supporting ruthenium demand.

Over the longer term, technological substitution is likely to add some downward pressure to the ruthenium price. However, ruthenium end-uses are well-diversified and long-term demand projections in other sectors such as chemicals and hydrogen more than offset the estimated losses attributed to the HDD market.



PRECIOUS METALS REVIEW

79 Au Gold

| | Close | Weekly change | High | Date | Low | Date |
|-------|-------|---------------|-------|------------|-------|------------|
| \$/oz | 1,762 | -3.33% | 1,832 | 04/08/2021 | 1,759 | 06/08/2021 |
| €/oz | 1,498 | -2.47% | 1,540 | 04/08/2021 | 1,496 | 06/08/2021 |

Central bank gold buying has picked up. Interest from central banks brought net buying to 333.2 t during the first half of 2021, with almost two-thirds concentrated in Q2'21. Global gold reserves grew by 199.9 t during Q2, the highest level of quarterly net purchases since Q2'19 and 73% above the five-year quarterly average. Purchasing was led by Thailand (90.19 t), Hungary (62.09 t) and Brazil (53.74 t) during the first half of the year (source: World Gold Council, IMF). In line with these significant purchases, there are reports that the

Polish central bank is looking to buy at least 100 t of gold at some point over the next few years. Overall, the outlook for this sector of gold demand in 2021 is more positive than it was at the start of the year, and central banks are expected to continue as net purchasers during H2'21. The gold price pulled back last week as signs of economic recovery in the US continue to tarnish appeal of bullion; US non-farms payroll (NFP) data for July came in well above expectations and unemployment is now at its lowest level since before the pandemic.

47 Ag Silver

| | Close | Weekly change | High | Date | Low | Date |
|-------|-------|---------------|-------|------------|-------|------------|
| \$/oz | 24.32 | -4.81% | 26.00 | 04/08/2021 | 24.20 | 06/08/2021 |
| €/oz | 20.68 | -3.96% | 21.86 | 04/08/2021 | 20.56 | 06/08/2021 |

Is reduced activity in China weighing on the silver price? Manufacturing PMI data for China fell below expectations in July, recording 50.3 compared to the 51.0 forecast, and down from 51.3 in June. The higher cost of raw materials, supply chain issues and flooding in key manufacturing regions are all expected to be contributing to reduced output recently. Overall, the economy is estimated to expand by 8.4% this year, a downward revision to earlier forecasts which is attributed to domestic weakness and slower exports during Q2'21. China's credit impulse has also turned down, which suggests a slowdown in infrastructure and

plant investment and typically marks a turning point in economic activity. The global industrial sector is the largest silver market, representing 486.8 moz last year and 54% of total demand. Of this, China is the second-largest demand region, accounting for 111.4 moz, or 22% of global industrial demand in 2020 (source: The Silver Institute). After a strong start to the year, a slowdown in China's economic activity could add pressure to the silver price moving into H2'21. Silver followed gold's descent even lower last week on signs that the US economy is strengthening, with the release of better-than-expected employment statistics.

78 Pt Platinum

| | Close | Weekly change | High | Date | Low | Date |
|-------|-------|---------------|-------|------------|-----|------------|
| \$/oz | 986 | -5.75% | 1,071 | 02/08/2021 | 978 | 06/08/2021 |
| €/oz | 838 | -4.91% | 901 | 02/08/2021 | 831 | 06/08/2021 |

Sibanye-Stillwater's South African PGM production increased by 41% year-on-year in H1'21. Output of 4E¹ PGMs from the Group's SA mines was 929 koz, including an estimated 560 koz of platinum. This marks a significant improvement from the same period last year (658 koz 4E), when operations were impacted by pandemic-related disruption including a three-week lockdown. Based on performance in the first half of the year, Sibanye-Stillwater appears to be on track to comfortably meet its SA PGM guidance for 2021 of 1.75-1.85 koz 4E. In H1'21, 2E¹ PGM production from the Group's US operations was 298 koz, flat year-on-year

owing to a 21-day safety-related work stoppage in June, which reduced output by ~20 koz 2E (an estimated 5 koz Pt and 15 koz Pd). The impact of downtime at Stillwater is forecast to bring full-year production toward the lower end of the Group's US PGM guidance for 2021 (670-690 koz 2E). The platinum price has dropped below \$1,000/oz for the first time this year, and is expected to move slightly lower over the next few months in line with its seasonal trend.

¹4E refers to platinum, palladium, rhodium and gold. 2E refers to platinum and palladium.



PRECIOUS METALS REVIEW

⁴⁶ Pd **Palladium**

| | Close | Weekly change | High | Date | Low | Date |
|-------|-------|---------------|-------|------------|-------|------------|
| \$/oz | 2,649 | 0.10% | 2,712 | 03/08/2021 | 2,637 | 03/08/2021 |
| €/oz | 2,247 | 0.76% | 2,276 | 03/08/2021 | 2,225 | 03/08/2021 |

Biden's tighter emissions targets limit the upside for ICE and palladium demand. US President Biden plans to sign an executive order setting a target for half of all new vehicles sold in the US in 2030 to have zero emissions, which includes battery electric, fuel cell and plug-in hybrid vehicles. The move is expected to restore and strengthen regulations to the level that existed during the Obama Administration. In a sign of industry support, the country's top three carmakers, General Motors, Ford Motor Co. and Stellantis, confirmed in a joint statement that they are working towards a target of 40-50% of their US sales being electric by 2030, but this requires significant government support, including consumer subsidies and EV charging infrastructure. The US, the world's second-largest vehicle market and currently dominated by gasoline cars, has lagged China and Europe in EV uptake. EVs currently account for just 2% of the US

light-vehicle market, compared to 6% in China and 10% in Europe. The largest barriers to uptake in the US to date have been concerns about range, which is compounded by a lack of charging infrastructure, as well as limited availability of the EVs that appeal to American consumer preferences (SUVs, pickups).

In the near term, powertrain evolution in the US is positive for PGMs, with the growth of hybrids (which also have a gasoline engine) more than offsetting the lost ICE-only vehicles and the gain in BEVs. However, considering Biden's renewed emissions targets for 2030, this trend is likely to be short-lived and gasoline vehicles could start to lose ground to BEVs sooner than expected. Currently, the US is the second-largest autocatalyst palladium demand market, forecast to reach 1.7 moz this year.

⁴⁵ Rh ⁴⁴ Ru ⁷⁷ Ir **Rhodium, Ruthenium, Iridium**

| | Rhodium | Ruthenium | Iridium |
|----------------|-------------|-----------|------------|
| Reporting week | \$20,450/oz | \$795/oz | \$5,850/oz |
| Previous week | \$19,850/oz | \$795/oz | \$5,850/oz |

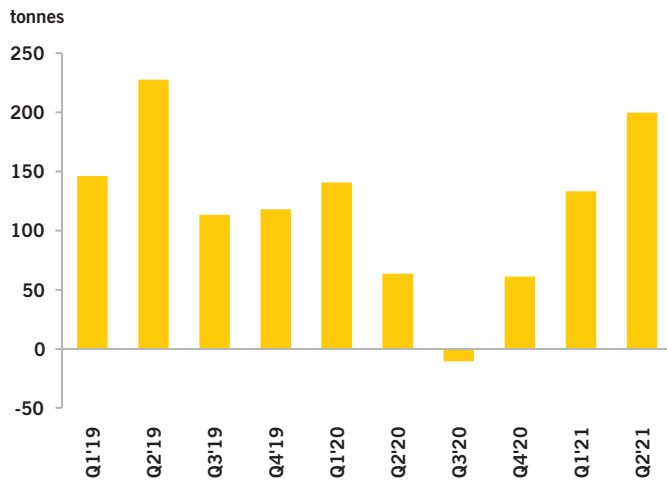
High metal prices are incentivising supply creep in South Africa. Despite their low grade, recovery of tailings (the waste material from mining) is an attractive proposition for PGM producers at current prices. Growing production – albeit in low volumes – from these sources is expected to keep iridium and ruthenium output from South Africa

topped up in the near term. Iridium and ruthenium production from tailings has shown strong growth over the past five years and is estimated to reach ~30 koz of ruthenium and ~20 koz of iridium this year. The iridium and ruthenium prices remained unchanged last week, while rhodium nudged up above \$20,000/oz.



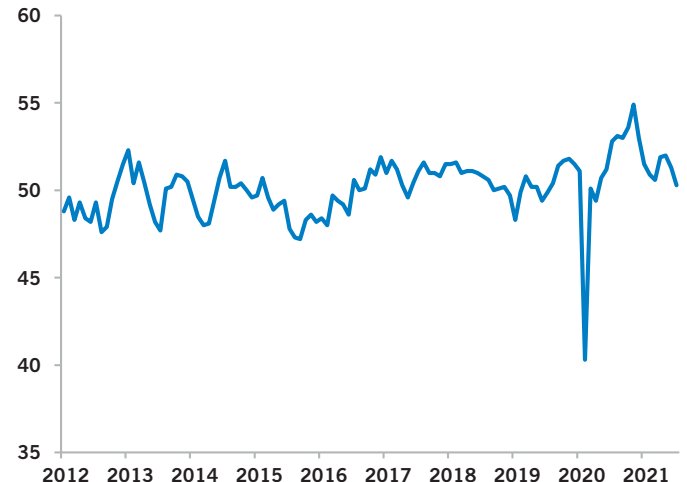
TRENDS AND INVESTMENTS

Central bank gold demand



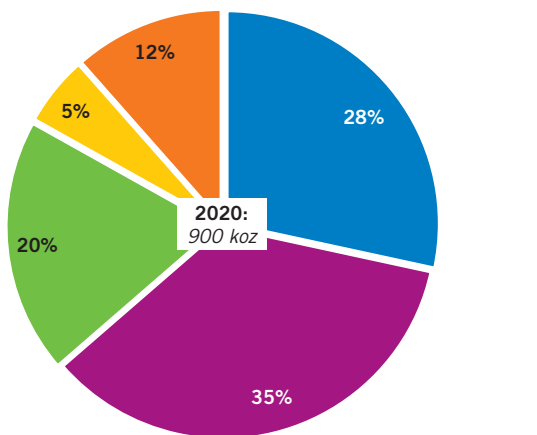
Source: World Gold Council, IMF

China manufacturing PMI



Source: SFA (Oxford), Bloomberg

Ruthenium demand by sector



■ Chemical ■ Electrical ■ Electrochemical ■ Hydrogen ■ Other
2020: 900 koz
Source: SFA (Oxford)

Ru & Ir output from South Africa



Source: SFA (Oxford)

Heraeus Precious Metals

Europe, Middle East, Africa & other regions
Phone: +49 6181 35 2750
edelmetallhandel@heraeus.com

South East Asia
Phone: +852 2773 1733
tradinghk@heraeus.com

www.herae.us/trading-market-report

Heraeus Precious Metals imprint can be found [here](#)

United States of America
Phone: +1 212 752 2180
tradingny@heraeus.com

China
Phone: +86 21 3357 5658
tradingsh@heraeus.com

The **HERAEUS PRECIOUS APPRAISAL** produced in collaboration with:

SFA (Oxford) Ltd
United Kingdom
Phone: +44 1865 784366
www.sfa-oxford.com



The Oxford Science Park, Oxford,
United Kingdom, OX4 4GA

DISCLAIMER

This document is being supplied to the recipient only, on the basis that the recipient is reasonably believed to be a professional market participant in the precious metals market. It is directed exclusively at entrepreneurs and especially not intended for the use of consumers. The material contained in this document has no regard to the specific investment objectives, financial situation or particular need of any specific recipient or organisation. It is not provided as part of a contractual relationship. It is not and should not be construed as an offer to sell or the solicitation of an offer to purchase or subscribe for any investment or as advice on the merits of making any investment. This report has been compiled using information obtained from sources that Heraeus and SFA (Oxford) Ltd ("SFA") believe to be reliable but which they have not independently verified. Further, the analysis and opinions set out in this document, including any forward-looking statements, constitute a judgment as of the date of the document and are subject to change without notice. There is no assurance that any forward-looking statements will materialize. Therefore,

neither SFA nor Heraeus warrants the accuracy and completeness of the data and analysis contained in this document. Heraeus and SFA assume no liability for any losses or damages of whatsoever kind, resulting from whatever cause, through the use of or reliance on any information contained in this document. However, in so far as a liability claim exists under German law, Heraeus and SFA shall have unlimited liability for willful or grossly negligent breach of duty. Unless expressly permitted by law, no part of this document may be reproduced or distributed in any manner without written permission of Heraeus. Heraeus specifically prohibits the redistribution of this document, via the internet or otherwise, to non-professional or private investors and neither Heraeus nor SFA accepts any liability whatsoever for the actions of third parties in reliance on this document. Prices quoted are interbank (offer) prices for gold, silver, platinum and palladium. Rhodium, ruthenium and iridium quotes reflect the Heraeus offer price at the time of writing.