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Crystalline osmium as a new asset class from the precious metals sector

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Abstract
Crystalline osmium represents a new addition to the spectrum of physical precious metal investments. As the densest stable element in the periodic table, it was not used commercially for a long time due to the assumed toxicity of its oxide (osmium tetroxide). Only the technological development of controlled crystallization processes since the 2010s made it possible to process and standardize this precious metal safely. This study examines the material science properties, toxicological safety, and economic relevance of crystalline osmium in comparison to classic precious metals such as gold, silver, or platinum.
The analysis focuses on the chemical inertness and abrasion resistance of crystalline osmium structures as well as their complete inability to oxidize to osO_4 under normal environmental conditions. These properties have been confirmed by long-term stability tests, thermogravimetric tests, and independent testing institutes. The evaluation is complemented by a systematic market analysis: Despite limited production volumes and low market liquidity, crystalline osmium offers a unique profile as a long-term tangible asset and the jewelry industry due to its certified distinctiveness, high-value density, and stable storability.
The paper argues that crystalline osmium - due to its scientifically proven harmlessness and its clear, unique selling point in the precious metals sector - forms an asset class in its own right. It is particularly suitable for highly diversified portfolios of physical real assets and, at the same time, represents a scientifically and regulatory secure precious metal investment.

Keywords
Precious metals, Osmium, alternative assets, Finance

Introduction

Crystalline osmium is currently the focus of increased scientific attention within the precious metals sector. This is particularly due to its classification as the densest of all stable elements and its recent introduction to the global market as the last precious metal. Although osmium was discovered as early as 1804 by Smithson Tennant (Wisniak, 2015; Pelclova, 2022), it was only with the development and perfection of specific crystallization processes between 1975 and 2012 that it became possible to process and reliably certify this element. These technological advances have established crystalline osmium as a suitable material for both the production of exclusive jewelry and capital investment in physical assets. Its introduction to international markets was accompanied by US customs and specialized institutions that ensure uniform certification, monitor purity standards, and provide legal clarity for transportation and trade.

Despite the relative novelty of crystalline osmium for asset managers and producers of luxury goods, extensive research has already been done on its safety-related suitability. Laboratory analyses of its chemical and physical properties clearly show that crystalline osmium is chemically inert and does not allow the formation of osmium tetroxide. This oxide could otherwise pose health risks, especially when raw or powdered osmium is used. As a result, crystalline osmium is scientifically proven to be nontoxic, harmless, and safe for long-term use in high-quality products such as jewelry and watches.

Due to its exceptional rarity, characteristic optical reflection properties, and abrasion resistance, crystalline osmium has quickly established itself as a special element among precious metals. Therefore, it deserves increased attention from the point of view of both scientific research and diversifying investment practice.

This paper focuses on two central questions: Firstly, the harmlessness of crystalline osmium, in particular with regard to its non-toxicity, is examined in detail. This clarifies whether and under what conditions the metal can be classified as harmless to health for long-term use in consumer and tangible asset investment products. Secondly, building on this toxicological assessment, an analysis of the suitability of crystalline osmium as an independent asset class within the group of precious metals is carried out. In this context, physical, economic, and regulatory aspects are considered when evaluating the metal's potential as a long-term tangible asset.

Precious metals

Precious metals are a group of rare metallic elements with high economic and functional value. Their outstanding physicochemical properties – such as high density, exceptional corrosion resistance, electrical conductivity, and chemical inertness – make them indispensable in numerous high-tech and industrial sectors (Sicius, 2018). These properties, coupled with their low availability in the earth's crust, result in a high market value and limited use in areas where no functional alternatives exist or only the smallest amounts of material are needed. In general, eight elements are classified as precious metals: gold (Au), silver (Ag), platinum (Pt), palladium (Pd), rhodium (Rh), ruthenium (Ru), iridium (Ir), and osmium (Os).

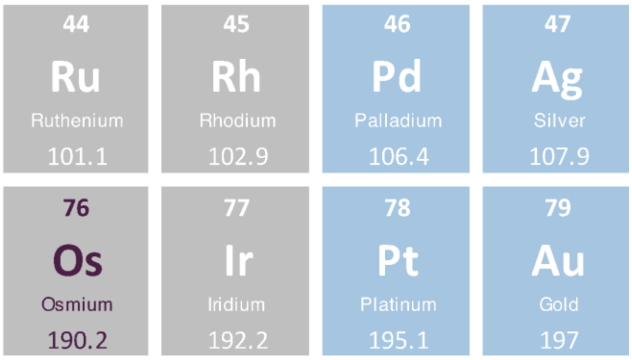

Fig. 1. Precious Metals overview (Osmium-Shop.at).

They occupy a characteristic position on the periodic table, spanning two periods and four groups. Within this group, all metals except gold and silver are considered platinum group metals (PGM). These metals have in common that they are formed under extreme geological conditions and occur in primary sulfide deposits or as byproducts in nickel, copper, and platinum ores (USGS, 2023; Pelclova, 2022).

The properties of precious metals usually differ significantly from those of conventional metals in two key areas: melting point and density. For example, the melting point of steel (a low-alloy iron-based material) is around 1537°C, with a density of around 7.8 g/cm³. In comparison, the precious metals in this group show significantly higher values in some cases, which underlines their special physical properties. These characteristics – especially in combination with their pronounced resistance to chemical attack – clearly distinguish precious metals from most other materials in the periodic table (see Tab. 1).

Tab. 2. Basic Properties of Precious Metals

Name	Symbol	Atomic Number	Crystal Structure	Melting Point, °C	Density g/cm³
Ruthenium	(Ru)	44	HCPP†	2334	12.45
Rhodium	(Rh)	45	FCC‡	1964	12.41
Palladium	(Pd)	46	FCC	1555	12.02
Silver	(Ag)	47	FCC	962	10.49
Osmium	(Os)	76	HCP	3033	22.61
Iridium	(Ir)	77	FCC	2443	22.56
Platinum	(Pt)	78	FCC	1768	21.45
Gold	(Au)	79	FCC	1064	19.32

The economic relevance of these metals varies greatly. While gold and silver have served as currency metals and stores of value for millennia, the platinum group metals are becoming increasingly important due to their function in industry, catalysis, electronics, and medicine. Their production requires significant investments in terms of capital expenditure, storage, and security costs. In large-scale applications, such as automotive catalysis or electronics production, the cost of precious metals can reach several million US dollars, making them a critical factor on corporate balance sheets (WPIC, 2024).

Tab. 2. Economic Parameters of Precious Metals.

Precious Metal	Main Producing Country	Form of Extraction	Market Price 2024 (USD/g)	Usage
Gold (Au)	China, Australia, Canada	Primary product/Placer deposit	83.8	Store of Value, Jewelry, Reserve Currency
Silber (Ag)	Mexico, China, Peru	Byproduct	0.93	Industry, jewelry, solar panels
Platin (Pt)	South Africa, Russia	Primary & Byproduct	29.11	Automotive catalysts, jewelry
Palladiu m (Pd)	South Africa, Russia	Byproduct	28.99	Automotive industry, electronics
Rhodium (Rh)	South Africa	Byproduct	163.91	Catalysts, sensors
Iridium (Ir)	South Africa, Canada	Byproduct	167.97	Medical technology, Chemicals
Osmium (Os)	Russia, Canada, South Africa	Byproduct (crystallized)	1682.37	Jewelry, tangible assets, research

This article focuses on osmium, the rarest element in the group. Although it was discovered in the early 19th century, it could not be used industrially or economically for a long time due to its properties in its raw form, which are harmful to health. It was only with the development of crystallization technology from 2012 onwards that a stable, manageable, and certifiable form was created – crystalline osmium, which is now increasingly establishing itself as a new physical asset class (Osmium Institute, 2025; Sicius, 2018). The exception had been the usage of Osmium as filaments in light bulbs under the brand name OSRAM. Other applications like fountain pen tips or record needles had never reached industrial volume. All three technologies have been replaced by electronic solutions nowadays.

Material and Methods

To investigate the chemical inertness and toxicological safety of crystalline osmium, as well as its potential as a distinct asset class, two complementary methodological approaches were adopted: (1) experimental materials testing (e.g., thermogravimetric analysis, long-term stability experiments) and (2) quantitative financial analysis (e.g., rolling window volatility and correlation measurements). Both parts aim to generate a robust data set to evaluate crystalline osmium from a materials science and investment perspective.

Financial Data Collection and Analysis

To assess the suitability of crystalline osmium as an investment asset, daily price time series were compiled from the date of the first recorded crystalline osmium price through the end of the observation period

(November 6, 2017, to March 20, 2025). Standard statistical and econometric methods were applied to examine volatility and correlation characteristics.

The data for the calculations comes from the Refinitiv EIKON financial database for the stock indices, from the www.westmetall.com platform for the precious metals gold and silver, and from the official price list at www.osmium-preis.com for crystalline osmium.

Results and Discussion

Osmium and Crystalline Osmium

The discovery of osmium at the beginning of the 19th century coincided with only limited industrial use. Historically, raw osmium – especially in powdered "sponge form" – posed a significant health and storage risk due to its tendency to oxidize to osmium tetroxide. Only with breakthroughs in crystallization technology around 2012 was this problem solved, enabling the conversion of the metal into a solid, closed crystal structure. This crystalline modification paved the way for the worldwide market launch between 2013 and 2019, accompanied by the international Osmium Institutes, which certify each piece using a unique identification code and high-resolution scans. The immutable physical surface of the crystal structure itself represents the identification key. Since then, osmium has increasingly been perceived not only as a scientific curiosity but also as an economically viable and unforgeable material.

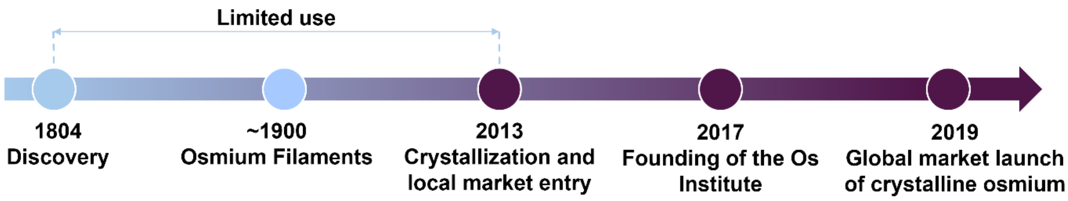

Fig. 3. Historical milestones of osmium and crystalline osmium.

Crystalline osmium has a density of 22.61 g/cm³ at the lowest temperatures, the highest known density of any metal. Its flat crystalline surface gives the material both a high and extremely parallel light reflection and exceptional structural stability. Numerous laboratory tests – including thermal, mechanical, and chemical stress tests – have shown that crystalline osmium remains inert at temperatures reaching up to 400°C. Furthermore, neither outgassing of osmium tetroxide nor measurable mass loss under long-term exposure to heat and humidity were detected. These results place crystalline osmium in a category of its own among noble materials with exceptional resistance to environmental influences – ideally suited for use in jewelry, watches, and specialized art objects.

Fig. 3. Crystalline osmium (Osmium-Deutschland.de).

Chemical Inertness and Toxicological Safety of Crystalline Osmium

Concerns about the possible toxicity of osmium are largely based on the substance osmium tetroxide (OsO_4), a strong oxidizing, volatile oxide that can be formed from powdered or porous raw osmium at room temperature by oxidation with atmospheric oxygen. This oxide is considered to be irritating to the eyes, respiratory tract, and mucous membranes (McLaughlin et al., 1946; Smith et al., 1974).

In contrast, crystalline osmium shows no tendency to form OsO_4 – even at elevated temperatures and when exposed to pure oxygen. In thermogravimetric studies, no measurable oxidation could be detected up to a temperature of 400°C (SETARAM, 2018). The crystalline structure forms a closed surface without pores or nanostructures, effectively preventing a reaction with oxygen (Osmium-Institute, 2025).

The Osmium Institute in Murnau conducted extensive long-term laboratory tests over a period of ten years. 4,000 samples of different ages, degrees of crystallization, and storage conditions were tested. The results can be summarized as follows:

- No change in mass over ten years in contact with air,
- No formation of osmium tetroxide even on contact with plastic packaging (no odor, no discoloration),
- No surface changes when exposed to sweat, chlorine, synthetic acids, heat, or humidity (Timelab 2018).

These results have been confirmed by independent testing laboratories such as Timelab – Laboratoire Officiel Suisse in accordance with ISO/CEI 17025. No reaction could be detected even under simulated conditions of tropical heat, thermal shock, or the influence of sulfur.

Toxicological literature also confirms the clear differentiation between raw osmium ("osmium sponge"), metallic osmium, and crystalline osmium. While the sponge form, in particular, tends to oxidize due to its porous structure and can form osmium tetroxide (OsO_4) under atmospheric oxygen, crystalline osmium has a closed, stable lattice structure that does not allow oxidation. In the early years of its market launch, however, the metal, sponge, and crystalline osmium were often mistakenly confused with the harmful oxide in popular scientific publications – a mistake that can be traced back to insufficient differentiation and a lack of reliable sources.

The toxicological literature confirms the differentiation between raw osmium and crystalline osmium. The Handbook on the Toxicology of Metals, for example, states: "In its nontoxic crystalline form, osmium has become important in watch and jewelry manufacture." (Pelclova, 2022)

The University of Cambridge (CCDC) and studies from the Journal of the Less Common Metals also emphasize that compact osmium in a solid crystalline form remains inert up to over 600°C and thus does not convert into osmium tetroxide (source: Jehn 1984 and CCDC 2023).

Tab. 3. Summary of the results of toxicological studies of crystalline osmium.

Source/Institution	Type of research	Result
McLaughlin et al. (1946); Smith et al. (1974)	Assessment of the toxicity of osmium tetroxide (non-crystalline osmium)	Only osmium tetroxide is toxic – crystalline form remains inert
Jehn, H. (1984)	Investigation of the high-temperature behavior of platinum group metals	Crystalline osmium remains stable up to temperatures of over 600°C.
SETARAM Instrumentation (2018)	thermogravimetric analysis (TGA)	No change in mass up to 400°C, no outgassing of OsO_4
Timelab – Laboratoire Officiel Suisse (2018)	Certified testing according to NIHS96-50 for chemical stability and long-term behavior	No reaction on contact with air, no oxidative disintegration
Pelclova, D. (2022)	Toxicological expert opinion in Handbook on the Toxicology of Metals	Crystalline osmium is inert, nontoxic, suitable for watches and jewelry
Osmium-Institut (2025)	Long-term observation, contact and oxidation tests on 4,000 samples	No formation of OsO_4, no change in mass, no reaction with air, moisture, sweat, acids

Crystalline Osmium as an Asset Class

Crystalline osmium represents a distinct and clearly definable asset class within the group of precious metals. Its physical, structural, and economic characteristics clearly distinguish it from traditional forms of investment such as gold, silver, or platinum. With a density of 22.61 g/cm³, osmium outperforms all known stable elements. It also has a flat-crystallized, anisotropic surface characterized by high optical reflectance. This property is aesthetically striking and forms the basis for a material-immanent anti-counterfeiting measure: each piece of crystalline osmium reflects light in a unique, microscopically detectable pattern.

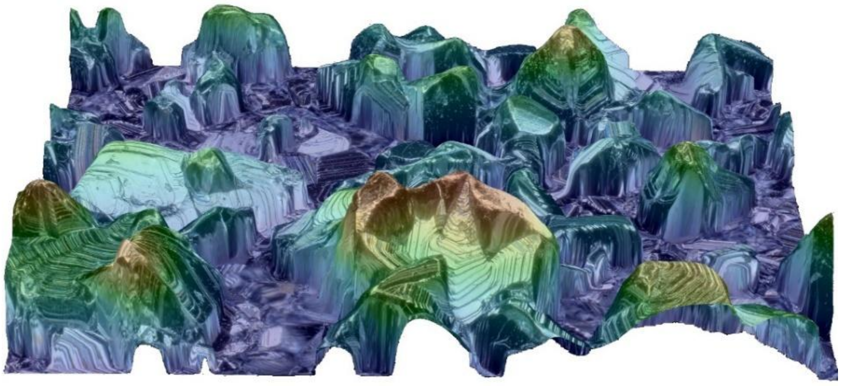

Fig. 4. Distinct microscopic structure of crystalline osmium (Osmium-Realestate.com).

Another unique selling point of crystalline osmium is the scarcity of supply. Industrial production is limited to a few kilograms per year, as osmium, in the earth's crust, is one of the rarest metals on earth (Sicius, 2018). Crystalline osmium is also clearly classified from a regulatory perspective: in its certified form, it is not subject to classification as a hazardous substance under the EU chemicals regulation REACH. This legal clarification is crucial for the international movement of goods and for duty-free import into numerous countries. Last but not least, there are also tax advantages: in Germany, crystalline osmium is treated as an "other movable asset". Capital gains are thus tax-free after a holding period of twelve months (Section 23 of the German Income Tax Act (EStG)), which parallels the tax treatment of physical investment gold.

Although a large number of scientific publications are available on the precious metals gold and silver (Adekoya et al., 2023; Bedoui et al., 2020; Bhatia, 2020; Cheng, 2022; Rehman, 2018; Salisu, 2021; Alqaralleh & Canepa, 2022), research on crystalline osmium as an asset class is extremely limited. With the exception of a paper by Ljuba Jakić (2021) in the journal Bankarstvo, we are currently unaware of any other relevant scientific publications that systematically address osmium in the context of investment or portfolio theory.

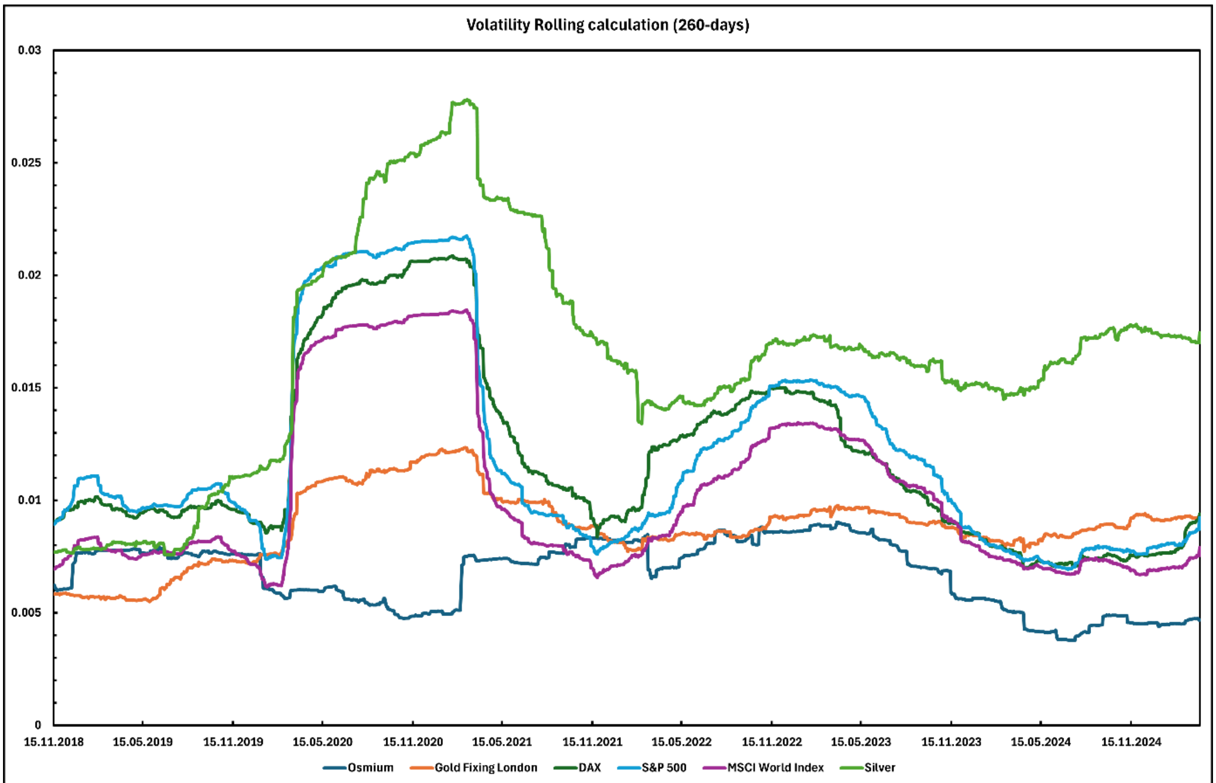

Fig. 5 Rolling Volatility 2018-2025.

From a portfolio theory perspective, crystalline osmium offers interesting diversification potential as an alternative asset class, particularly due to its volatility structure and low correlation compared to established precious metals such as gold and silver. As can be seen from the following figures, both the volatility and the correlations to benchmark metals were calculated for the period from November 6, 2017 (the first available market price for crystalline osmium) to March 20, 2025, based on constant daily returns for 260 trading days. In order to visualize the temporal dynamics of these key figures, a rolling calculation of the respective 260-day windows was carried out. The time series shown thus reflects the moving development of volatility and correlation in the period from November 15, 2018, to March 20, 2025, enabling a more precise assessment of the stability and diversification potential of crystalline osmium in an investment context.

What is striking is the consistently significantly lower volatility of crystalline osmium compared to selected precious metal investments such as gold and silver, but also compared to leading stock indices such as the DAX, the MSCI World Index, and the S&P 500 Index. Correlations were calculated for all three precious metals in relation to the performance of the S&P 500 Index. Here, too, the diversification potential of crystalline osmium is evident since the rolling correlation remained low over the entire observation period and was significantly lower than the comparative values of the other metals. This underlines the potential suitability of osmium as an asset class that is not or only weakly correlated with stock markets in the sense of risk-adjusted portfolio optimization.

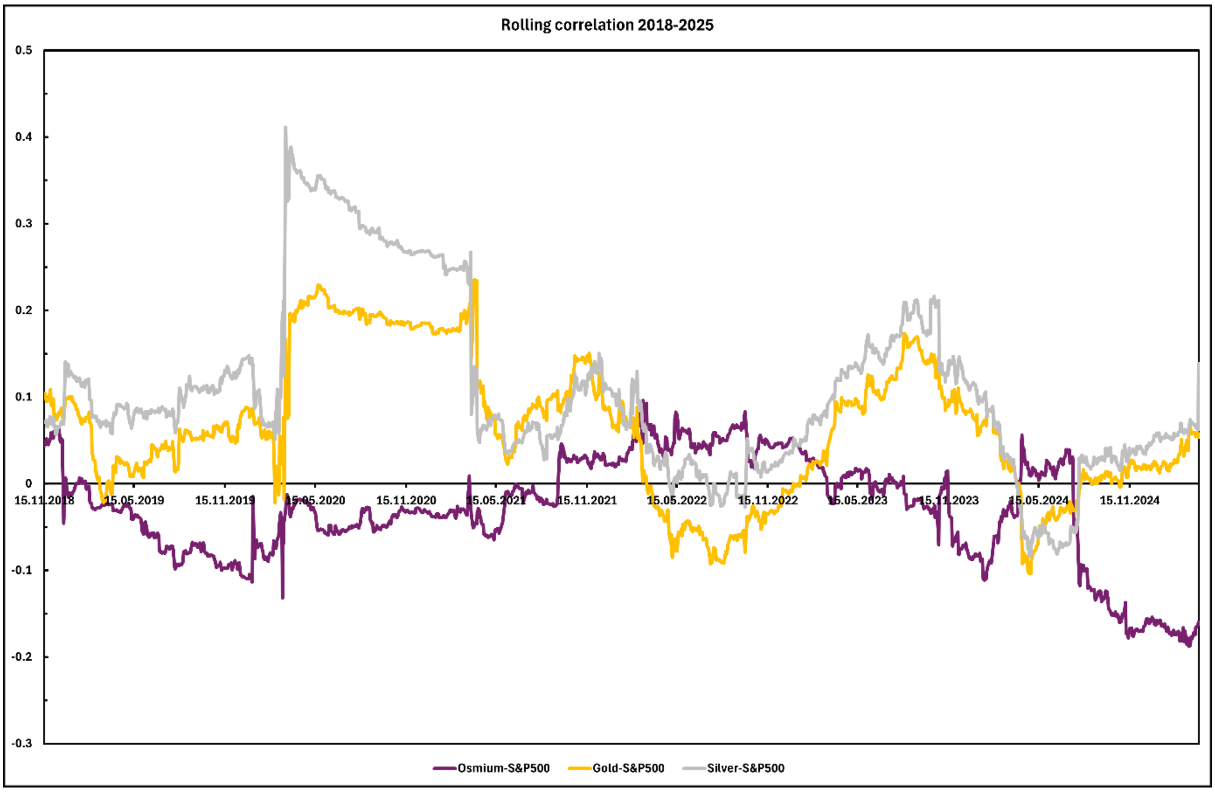

Fig. 6 Rolling Correlation 2018-2025.

In contrast to other precious metals, which are represented as asset classes in portfolios, crystalline osmium is considered to be forgery-proof and traceable. The Osmium Identification Code (OIC) gives each certified piece of crystalline osmium a unique signature that is managed in an international database. This form of digital ownership assurance provides a legally compliant, traceable proof of ownership that also meets regulatory requirements in the area of money laundering prevention (source: Osmium Institute 2025). Crystalline osmium is introduced to the world market in accordance with ESG-M standards and following the US rulings. While gold, silver, platinum, and palladium continue to be among the traditional forms of investment, crystalline osmium is becoming increasingly important for investors pursuing diversification strategies and specifically targeting non-forgeable precious metals with high-value density. With regard to the use of crystalline osmium as an asset class, the central question for future research is the portfolio view of this new asset class.

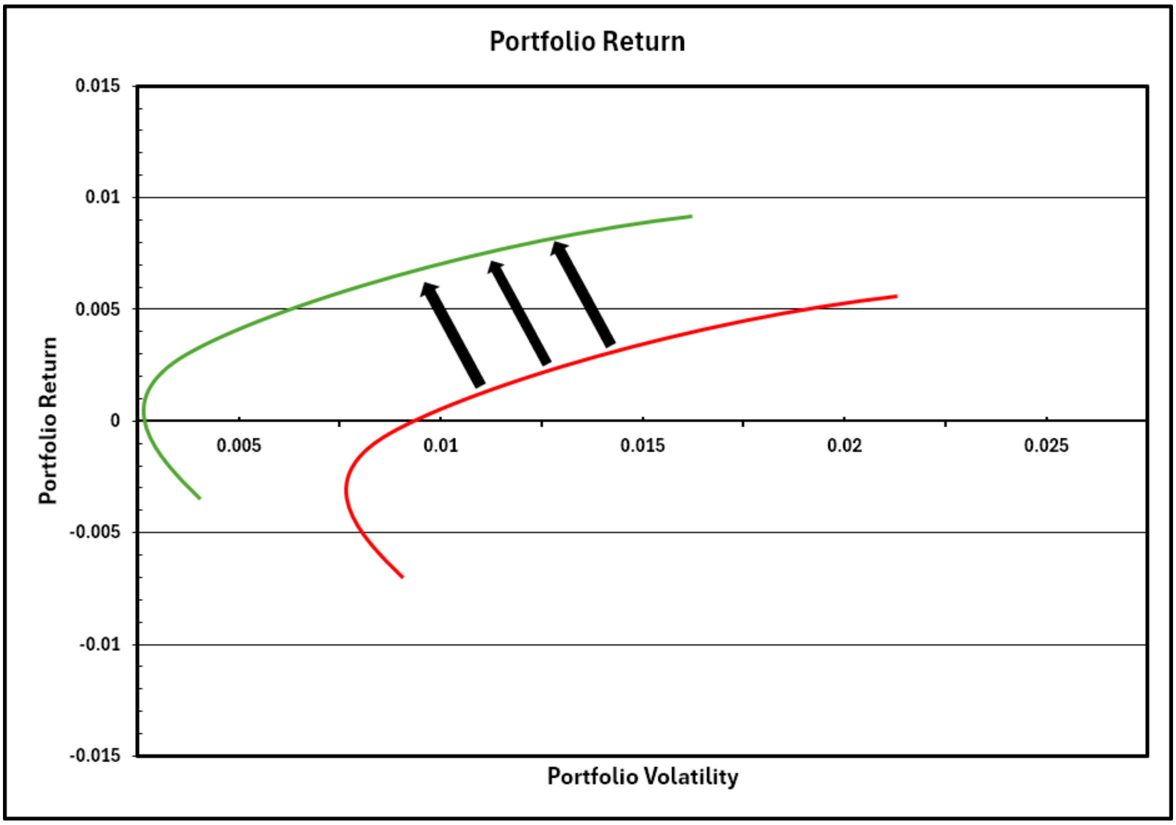

Fig. 7 Efficiency line shift per Markowitz – 1952.

The analysis focuses on whether crystalline osmium can serve as a useful component of a diversified investment portfolio from a risk-return perspective. Particular attention is paid to the potential for portfolio stabilization through low or even negative correlations to traditional precious metals such as gold or platinum, as well as to selected stock indices. Such correlation-based diversification effects can contribute to improving the efficient frontier and thus enable the optimization of the overall portfolio in line with modern portfolio theory. Crystalline osmium is thus not only considered as an isolated asset class but also analyzed in terms of its strategic contribution to the risk-return balance of mixed real asset portfolios.

Conclusions

This paper addresses two key issues: firstly, the toxicological and chemical safety of crystalline osmium is examined, particularly with regard to its safe use in consumer and investment products. Secondly, based on these results, the suitability of crystalline osmium as an independent asset class within the precious metal group is analyzed. The focus is on its physical properties, market structure, and possible diversification effects in the context of modern portfolio theory. With regard to the first objective, a literature analysis showed that crystalline osmium, in its stable, flat crystallized form, is chemically inert and harmless to health. Several laboratory studies, including thermogravimetric analyses by SETARAM and long-term investigations by the Osmium-Institute and Timelab, show that crystalline osmium does not form any reactive oxidation products – even at elevated temperatures or under the influence of humidity, sweat, or synthetic acids. The formation of osmium tetroxide, which has been associated with toxicological risks in the past, is ruled out under these conditions. This fulfills the prerequisite for long-term and safe use in high-quality consumer goods such as watches and jewelry, which is also supported by the international scientific literature. Crystalline osmium is neither harmful to health nor does it cause allergies.

The second objective – the valuation of crystalline osmium as an asset class – can also be answered positively. The combination of extreme density, a crystal structure that cannot be counterfeited, digital ownership traceability via the Osmium Identification Code, and a globally coordinated market structure establish a consistent investment profile. The supply shortage and the clear regulatory classification (including no classification as a hazardous substance under the REACH regulation) create conditions that promote long-term value retention and market stability. In addition, due to its independence within the precious metal group, crystalline osmium potentially shows low correlations to traditional precious metals or stock markets. This makes it suitable as a strategic addition to real asset portfolios with a focus on diversification and inflation protection.

In summary, this article shows that crystalline osmium can be classified not only as a safe precious metal from a scientific and regulatory point of view but also as an independent, future-oriented asset class.

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