

MEDICAL MINERALOGY RESEARCH WITH AN ARTIFICIAL INTELLIGENCE CHATBOT: A PRELIMINARY EXPERIMENT

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Introduction

Artificial intelligence is being considered one of the most pressing issues of the moment both in terms of risks and opportunities; it has been hailed as a potential source of new discoveries and feared as a threat to authorship and originality. In the present work we make an exploratory study of the potential of Microsoft Bing with GPT-4 to search for potential uses of minerals for medical purposes. In the following sections we present the original question (Q) and Bing's answer (B). In some cases we follow some of Bing's suggestions for further discussion of a given subject. All text from authors is in black; all text from Bing (including suggested questions) is in blue. It would certainly look strange to have a poster with text only, but we think this is the best way to show Bing's answers, which might be quite long.

Propose 10 original projects, which have not been studied before, on Medical Mineralogy.

Medical mineralogy is a fascinating and emerging field of study that explores the interactions between minerals and living systems, both in health and disease. Here are some possible original projects that have not been studied before, as far as I know:

- The role of mineral nanoparticles in the formation and propagation of amyloid plaques in Alzheimer's disease. This project would investigate the hypothesis that certain minerals, such as iron oxide or silica, can act as nucleation sites or catalysts for the aggregation of amyloid-beta peptides in the brain, and how this process can be modulated by environmental or genetic factors.
- The effects of mineral dust exposure on the microbiome of the respiratory tract. This project would examine how inhaling different types of mineral dusts, such as asbestos, coal, or volcanic ash, can alter the composition and function of the microbial communities that inhabit the lungs and airways, and how this can influence the susceptibility to respiratory infections or diseases.
- The biomineralization of coral reefs under ocean acidification. This project would explore how the changing chemistry of seawater due to increased carbon dioxide levels affects the formation and dissolution of calcium carbonate minerals in coral skeletons, and how this impacts the biodiversity and resilience of coral reef ecosystems.
- The geochemistry of arsenic in drinking water sources and its implications for human health. This project would analyze the spatial and temporal variations of arsenic concentrations and speciation in groundwater and surface water sources, and how they are influenced by geological, hydrological, and anthropogenic factors. It would also assess the exposure and health risks of arsenic ingestion for different populations and regions.
- The development of novel bioceramics for bone tissue engineering. This project would design and synthesize new materials based on natural or synthetic minerals, such as hydroxyapatite, bioglass, or calcium phosphate, that can mimic the structure and properties of bone tissue, and promote its regeneration and integration with implants.
- The interaction of prions with soil minerals and its role in the transmission of prion diseases. This project would investigate how prions, which are infectious proteins that cause neurodegenerative diseases such as mad cow disease or Creutzfeldt-Jakob disease, can bind to and be stabilized by different soil minerals, such as clay or iron oxides, and how this affects their mobility and infectivity in the environment.
- The mineralogy of kidney stones and its relation to dietary and metabolic factors. This project would characterize the mineral composition, morphology, and crystallography of kidney stones from different patients, and correlate them with their dietary habits, metabolic profiles, and genetic predispositions. It would also explore potential strategies to prevent or dissolve kidney stones based on their mineralogy.
- The influence of mineral supplements on the bioavailability and toxicity of trace elements in humans. This project would evaluate how taking mineral supplements, such as iron, zinc, selenium, or iodine, can affect the absorption, distribution, metabolism, and excretion of these essential trace elements in the body, and how this can modulate their beneficial or harmful effects on human health.
- The formation and dissolution of dental calculus (tartar) and its role in oral health. This project would study how dental plaque, which is a biofilm composed of bacteria and organic substances, can mineralize into dental calculus by incorporating calcium phosphate minerals from saliva or food. It would also examine how dental calculus can affect the health of teeth and gums, and how it can be removed or prevented by mechanical or chemical means.
- The origin and evolution of biominerals in living organisms. This project would trace the phylogenetic history and molecular mechanisms of biomineralization in different groups of organisms, such as plants, animals, fungi, or bacteria. It would also compare the diversity and complexity of biominerals across different taxa and environments.

(1) Medical Mineralogy and Geochemistry - Mineralogical Society of America. <http://www.minsocam.org/MSA/RIM/Rim64.html>; (2) Medical Mineralogy and Geochemistry - De Gruyter. <https://www.degruyter.com/document/doi/10.1515/9781501509421/html>; (3) Medical Mineralogy and Geochemistry – Elements Magazine. <https://www.elementsmagazine.org/medical-mineralogy-and-geochemistry/>; (4) Minerals, Natural Environment, and Medical Geology. https://link.springer.com/chapter/10.1007/978-3-030-65706-2_2; (5) undefined. <https://doi.org/10.1515/9781501509421>

Propose 10 original projects, which have not been studied before, on the medical use of clay minerals.

Some possible original projects that have not been studied before, as far as I know, on the medical use of clay minerals are:- The use of clay minerals as adjuvants for vaccines. This project would explore the potential of clay minerals, such as montmorillonite or kaolinite, to enhance the immune response and protection against various infectious diseases by acting as carriers, stabilizers, or modulators of antigens and immunostimulants¹.- The use of clay minerals as inhibitors of viral replication. This project would investigate the ability of clay minerals, such as halloysite or illite, to interfere with the life cycle and infectivity of different types of viruses, such as influenza, herpes, or coronavirus².- The use of clay minerals as regulators of gut microbiota. This project would examine the effects of clay minerals, such as palygorskite or sepiolite, on the composition and function of the microbial communities that inhabit the gastrointestinal tract, and how this can influence the digestion, metabolism, and immunity of the host³.- The use of clay minerals as agents for wound healing and scar prevention. This project would evaluate the performance of clay minerals, such as bentonite or laponite, on the healing process and scar formation of various types of wounds, such as cuts, burns, or ulcers⁴.- The use of clay minerals as nanoreactors for enzyme immobilization and biocatalysis. This project would explore the application of clay minerals, such as vermiculite or hectorite, as nanoscale platforms for the immobilization and activation of enzymes, and how this can improve their stability, activity, and selectivity for various biochemical reactions.- The use of clay minerals as sensors for biomarker detection and diagnosis. This project would investigate the feasibility of clay minerals, such as chitosan-clay composites or clay-polymer nanofibers, as sensors for the detection and quantification of various biomarkers, such as proteins, hormones, or metabolites, that are associated with different diseases or disorders.- The use of clay minerals as modulators of gene expression and delivery. This project would examine the possibility of clay minerals, such as saponite or beidellite, as modulators of gene expression and delivery by interacting with DNA or RNA molecules, and how this can affect their structure, stability, and function in living cells.- The use of clay minerals as enhancers of skin permeability and transdermal drug delivery. This project would assess the effectiveness of clay minerals, such as smectite or kaolinite nanoparticles, on enhancing the permeability and penetration of the skin barrier by various drugs or cosmetic agents.- The use of clay minerals as inhibitors of amyloid aggregation and neurodegeneration. This project would study the potential of clay minerals, such as attapulgite or montmorillonite nanosheets, on inhibiting the aggregation and toxicity of amyloid peptides that are involved in neurodegenerative diseases such as Alzheimer's or Parkinson's.- The use of clay minerals as stimulators of angiogenesis and vascularization. This project would evaluate the role of clay minerals, such as hydrotalcite or layered double hydroxides, on stimulating the formation and growth of new blood vessels in various tissues or organs that require vascularization.Origem: conversação com o Bing, 09/10/2023(1) BENEFITS AND RISKS OF CLAYS AND CLAY MINERALS TO HUMAN ... - Springer. <https://link.springer.com/article/10.1007/s42860-021-00160-7>.(2) CLAYS AND HUMAN HEALTH. http://projects.itn.pt/Nanosar_30_Pub_PTDC_GEO_FIG_1822_2014/ICGT06.pdf.(3) Medicinal Clay Properties, Health Benefits, and Precautions. <https://remedygrove.com/traditional/Clay-Medicinal-Uses-in-History-and-Today>.(4) Clay mineral - Wikipedia. https://en.wikipedia.org/wiki/Clay_mineral.

Considering only well known and tested uses, indicate the most profitable (from the economic point of view) medical use of kaolin.

Kaolin is a type of clay that has various medical uses, such as treating diarrhea, oral mucositis, bleeding, and wound healing. According to one of the web search results¹, kaolin is used as a filler in tablets and as a filtering agent to clarify liquids. It is also used in pharmaceutical preparations as a wound dressing that can stop bleeding, prevent infection, and promote healing. Kaolin is also added to dusting powders and is used as a tablet excipient. Considering only well known and tested uses, the most profitable medical use of kaolin may depend on several factors, such as the demand, supply, cost, and quality of the product. However, based on the information available, one possible profitable medical use of kaolin is to use it as a wound dressing. This is because:- Wound care is a large and growing market, especially with the increasing prevalence of chronic wounds, such as diabetic ulcers, pressure ulcers, and venous leg ulcers².- Kaolin has been shown to be effective and safe for wound healing, as it can absorb fluids, stop bleeding, prevent infection, and promote healing³. Kaolin has also been approved by the FDA for use in wound dressings³.- Kaolin is abundant, inexpensive, natural, and biodegradable. It can also reduce the environmental impact of mining by recycling the waste materials⁴. Therefore, using kaolin as a wound dressing could be a profitable medical use for this material. However, it would also require further research and development to optimize and improve its use. (1) KAOLIN - Uses, Side Effects, and More - WebMD. <https://www.webmd.com/vitamins/ai/ingredientmono-44/kaolin>; (2) Kaolin Uses, Benefits & Dosage - Drugs.com Herbal Database. <https://www.drugs.com/npp/kaolin.html>; (3) Kaolinite - Wikipedia. <https://en.wikipedia.org/wiki/Kaolinite>; (4) Kaolin: Uses, Side Effects, Dose, Health Benefits, Precautions & Warnings. <https://www.emedicinehealth.com/kaolin/vitamins-supplements.html>; (5) Kaolin Pectin - Technical Report - Agricultural Marketing Service. <https://www.ams.usda.gov/sites/default/files/media/USDANOPKaolinPectin.pdf>

Estimate the market value of kaolin used for dressing wounds.

To estimate the market value of kaolin used for dressing wounds, I will use some data and assumptions from the web search results. According to [1]⁽¹⁾, the global kaolin market size was valued at USD 4.23 billion in 2022 and is projected to grow at a CAGR of 4.6% from 2023 to 2030. According to [2]⁽²⁾, wound dressing is one of the applications of kaolin, along with paper, ceramic & sanitary ware, fiberglass, paints & coatings, rubber, plastics, and others. According to [3]⁽³⁾, the average kaolin price in the U.S. was USD 160 per ton in 2022.

Assuming that the global kaolin market size and price grow at a constant rate of 4.6% and 2% per year respectively, and that the wound dressing application accounts for 10% of the total kaolin consumption (which is a rough estimate based on the relative demand of different applications), we can calculate the market value of kaolin used for dressing wounds as follows:

- The global kaolin market size in 2023 = USD 4.23 billion x (1 + 0.046) = USD 4.42 billion
- The average kaolin price in the U.S. in 2023 = USD 160 per ton x (1 + 0.02) = USD 163.2 per ton
- The global kaolin consumption in 2023 = USD 4.42 billion / USD 163.2 per ton = 27.09 million tons
- The kaolin consumption for wound dressing in 2023 = 27.09 million tons x 0.1 = 2.71 million tons
- The market value of kaolin used for dressing wounds in 2023 = USD 163.2 per ton x 2.71 million tons = USD 442.27 million

Therefore, based on these data and assumptions, the market value of kaolin used for dressing wounds in 2023 is estimated to be around USD 442.27 million. However, please note that this is not a precise or professional calculation, and it may vary depending on different sources, methods, and factors. (1) Kaolin Market Size, Share And Growth Analysis Report, 2030. <https://www.grandviewresearch.com/industry-analysis/kaolin-market>; (2) Kaolin Market Size, Growth | Global Industry Analysis [2030]. <https://www.fortunebusinessinsights.com/kaolin-market-102352>; (3) Average kaolin price U.S. 2022 | Statista. <https://www.statista.com/statistics/248194/average-price-of-kaolin/>

Propose 10 original projects, which have not been studied before, on the medical use of naturally occurring crystalline minerals.

The medical use of naturally occurring crystalline minerals is a very interesting and promising topic of research. Here are some possible original projects that have not been studied before, as far as I know:- The use of quartz crystals for wound healing and infection prevention. This project would explore the potential of quartz crystals, which have antibacterial, anti-inflammatory, and piezoelectric properties, to enhance the healing process and prevent infection in wounds, burns, or ulcers.

- The use of zeolites for drug delivery and detoxification. This project would investigate the ability of zeolites, which are porous aluminosilicate minerals that can adsorb and release various molecules, to deliver drugs to specific targets in the body or remove toxins from the blood or organs.
- The use of magnetite for magnetic resonance imaging and hyperthermia therapy. This project would examine the feasibility of magnetite, which is a magnetic iron oxide mineral that can generate heat when exposed to an alternating magnetic field, to improve the contrast and resolution of magnetic resonance imaging or induce localized hyperthermia in tumors or infections.
- The use of fluorite for optical coherence tomography and photodynamic therapy. This project would evaluate the performance of fluorite, which is a fluorescent calcium fluoride mineral that can emit light when stimulated by a laser, to enhance the imaging and treatment of various diseases or disorders in the eye, skin, or other tissues.
- The use of calcite for bone regeneration and osteoporosis prevention. This project would assess the effectiveness of calcite, which is a calcium carbonate mineral that is the main component of bones and shells, to stimulate bone growth and repair or prevent bone loss and fractures.
- The use of gypsum for wound dressing and hemostasis. This project would test the suitability of gypsum, which is a hydrated calcium sulfate mineral that can absorb water and form a gel-like substance, to cover and protect wounds or stop bleeding.
- The use of pyrite for electrochemical biosensors and biofuel cells. This project would explore the application of pyrite, which is an iron sulfide mineral that can conduct electricity and catalyze reactions, to detect or measure biomolecules or generate electricity from biological sources.
- The use of malachite for antioxidant and anticancer activity. This project would investigate the potential of malachite, which is a copper carbonate hydroxide mineral that has antioxidant and anticancer properties, to scavenge free radicals or inhibit tumor growth or metastasis.
- The use of tourmaline for ionizing radiation protection and enhancement. This project would study the possibility of tourmaline, which is a borosilicate mineral that can emit negative ions or infrared radiation when heated or pressurized, to shield or enhance the effects of ionizing radiation on living cells or tissues.
- The use of diamond for nanomedicine and biotechnology. This project would examine the advantages of diamond, which is a carbon allotrope that has exceptional mechanical, thermal, optical, and chemical properties, to create nanoscale devices or materials for various medical or biotechnological purposes.

What is the most promising project?

That is a very difficult question to answer, as all the projects are interesting and have potential benefits for human health and well-being. However, if I had to choose one, I would say that the project on the use of clay minerals as inhibitors of viral replication is the most promising one. This is because:- Viral infections are a major global health threat, especially in the context of the ongoing coronavirus pandemic, and there is an urgent need for effective antiviral agents that can prevent or treat viral diseases.- Clay minerals have been shown to have antiviral properties against various types of viruses, such as influenza, herpes, or coronavirus, by interfering with their attachment, entry, replication, or release from host cells.- Clay minerals are abundant, inexpensive, biocompatible, and environmentally friendly materials that can be easily applied or administered to infected individuals or populations. Therefore, I think that the project on the use of clay minerals as inhibitors of viral replication is the most promising one, as it could lead to the development of novel and safe antiviral therapies that could save millions of lives and reduce the burden of viral diseases.

What are some challenges of using clay minerals as antiviral agents?

Clay minerals are natural materials that have been shown to have antiviral properties against various types of viruses, such as influenza, herpes, or coronavirus²⁴. However, there are also some challenges of using clay minerals as antiviral agents, such as:- The mechanism of action of clay minerals against viruses is not fully understood, and may depend on several factors, such as the type and composition of the clay, the type and strain of the virus, the pH and temperature of the environment, and the presence of other substances or cells¹².- The safety and toxicity of clay minerals for human or animal use is not well established, and may vary depending on the source, purity, and dosage of the clay, as well as the route and duration of administration¹³. Some clay minerals may contain harmful impurities, such as heavy metals or radionuclides, or may interact with other drugs or nutrients in the body¹³.- The stability and bioavailability of clay minerals in different biological fluids or tissues is not well characterized, and may affect their antiviral efficacy and biodistribution¹². Some clay minerals may degrade or dissolve in acidic or alkaline conditions, or may be cleared or eliminated by the immune system or the excretory system¹².- The standardization and regulation of clay minerals for antiviral applications is not well developed, and may pose challenges for quality control, validation, and approval¹³. There is a lack of uniform criteria and methods for the characterization, classification, and evaluation of clay minerals for antiviral purposes¹³. These are some of the challenges of using clay minerals as antiviral agents. However, these challenges also provide opportunities for further research and development to optimize and improve the use of clay minerals for antiviral therapy. 1) BENEFITS AND RISKS OF CLAYS AND CLAY MINERALS TO HUMAN ... - Springer. <https://link.springer.com/content/pdf/10.1007/s42860-021-00160-7.pdf>.(2) Antibacterial Activity of a Natural Clay Mineral against. <https://www.mdpi.com/2076-2607/11/1/150>.(3) BENEFITS AND RISKS OF CLAYS AND CLAY MINERALS TO HUMAN ... - Springer. <https://link.springer.com/article/10.1007/s42860-021-00160-7>.(4) NATURAL ANTIBACTERIAL CLAYS: HISTORICAL USES AND MODERN ADVANCES - Springer. <https://link.springer.com/article/10.1007/s42860-018-0002-8>.(5) Frontiers | Natural Compounds With Antimicrobial and Antiviral Effect <https://www.frontiersin.org/articles/10.3389/fphar.2021.723233/full>.

Is there any data supporting the assumption that wound dressing represents 10% of the kaolin market?

I searched the web for the kaolin market share by application, but I could not find any data supporting the assumption that wound dressing represents 10% of the kaolin market. This assumption was based on a rough estimate of the relative demand of different applications, and it may not be accurate or reliable. The actual market share of wound dressing may vary depending on the source, region, and method of calculation. Therefore, I suggest that you use caution when using this assumption for any analysis or projection. (1) Kaolin Market Size, Share And Growth Analysis Report, 2030. <https://www.grandviewresearch.com/industry-analysis/kaolin-market>.(2) Kaolin Market - Size, Share & Growth - Mordor Intelligence. <https://www.mordorintelligence.com/industry-reports/kaolin-market>.(3) Kaolin Market Size, Share, Growth | Report, 2030. <https://www.marketresearchfuture.com/reports/kaolin-market-5865>.(4) Kaolin Market Size, Share, Growth & Industry Trends [2031]. <https://growthmarketreports.com/report/kaolin-market-global-industry-analysis>.(5) Kaolin Market Share, Demand, Analysis | Global Report, 2030. <https://www.valuemarketresearch.com/report/kaolin-market>.

Conclusions

Bing with GPT-4 showed itself to be an interesting tool for generating ideas, a kind of creative assistant without "writer's block" and writing in good English (albeit, curiously, MS Word flagged some portions of Bing's answers; nonetheless we let the original text from Bing). However, those ideas sometimes deserve skepticism and occasionally are truly baffling (quartz for treating wounds). Some of its suggestions seem also to be proposed without a significant support as the assu use mption of 10% of kaolin market for wound dressing. In a kind of upgrade from the classical "garbage in, garbage out", generative artificial tools seem to be able to "generate garbage" out of the available information. It seems clear that at least for the time being these tools will need a focused human supervision, but they could be important creativity prompts.

Acknowledgments

The Lab2PT-Landscapes, Heritage and Territory laboratory—UIDB/04509/2020 is supported by the Portuguese FCT—“Fundação para a Ciência e a Tecnologia”. The authors also gratefully acknowledge the support of the CERENA (funded by a strategic project of the FCT—UIDB/04028/2020) and the LAMPIST of the DECivil, Instituto Superior Técnico, University of Lisbon, Portugal. The University Institute of Geology of the University of A Coruña (Spain) receives support from the Xunta de Galicia from the program “Consolidación y estructuración de unidades de investigación competitivas: Grupos de potencial de crecimiento” (ED431B 2018/47 and ED431B 2021/17).



The 9th International Electronic Conference on Medicinal Chemistry

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