Engineering and Applied Science Letters

PSR Press

Article

Using Dowsing experimental technique (TED) to identify different minerals, metals, and other materials: Is it pure physics and chemistry (Applied Natural Sciences), or psychology (Human's Behavioral Science)?

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Received: 31 May 2025; Accepted: 23 June 2025; Published: 30 June 2025.

Abstract: Dowsing experimental technique (DET), also known as divination, has been used to serve human needs across different civilizations. A comprehensive review of the literature on DET indicates that scientists are divided into two groups, regarding DET's science and interpretation. One group believes that there is pure physics and chemistry behind DET and, therefore, it should be considered as one of the applied sciences used for materials' prospecting. The other group believes that identification of materials using DET can be explained as a psychological behavior. In this research paper, DET has been used to identify several materials, and the various possible mechanisms behind it also examined. Accordingly, 68 samples were collected from various locations in Jordan and Palestine to identify them using DET. The collected samples, including different kinds of minerals, metals, rocks, etc., were divided into 9 groups. Experiments were conducted on combinations of the collected materials, using wooden rods and two capsules filled with crushed materials and placed on the rods. It is believed that the materials were identified using DET because of energy radiation, thermal conduction, piezoelectric effects, and/or electrostatic forces. DET may be also interpreted in terms of psychological perspectives, as being a psychological kinesthetic sense. So that these forces may be able to move the rods towards the target material, identify it, and recognize its location. However, DET is still an open question for further research, including cyber-psychology and other digital tools. In short, DET has proven to be a successful, easy, cheap, applicable, and sustainable technique for identifying and locating various materials.

Keywords: different natural materials collected from Jordan and Palestine, eEnergy mechanisms: radiation, heat conduction, and piezoelectric effects, psychological perspectives, cyber-psychology and other digital tools, Dowsing experimental technique using wooden rods, historical review

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Highlights

This research paper

• Has reviewed a wide range of the literature related to two main issues that reflect its interests, namely the dowsing experimental technique (DET) using wooden rods (bars or sticks), and geophysics as a lead discipline of applied science and engineering in the field of natural resources' exploration and interpretation, as well as psychology science with respect to interpretation of the dowsing phenomenon, raising the question of potential use of cyber-psychology and other digital tools to serve DET.

• Has presented the results obtained from the field, using wooden rods to identify 68 materials (minerals, metals, rocks, etc.) divided into 9 different groups, based on chemical and mineralogical composition, and lithological properties.

• Has raised the question: What is/are the mechanism(s) that enable(s) the rods to recognize the examined materials? Ionizing (electromagnetic) radiation, thermal conductance, and piezoelectric effects are believed to be the mechanisms behind DET. Other reasons may include physiological perspectives, as being a psychological kinesthetic sense.

• Based on the samples and data used, as well as evidence and observations through on-site experiments and proofs, it has been shown that DET is a successful technique in locating the target materials and identifying them. However, cyber-psychology and other digital tools are considered as an open field for further investigations with respect to DET.

1. Introduction

1.1. Literature review: Dowsing experimental technique (DET)

The dowsing experimental technique (DET) is a technique that has been used for a long period of time to search and locate anything invisible, by observing the motion of a pointer (traditionally a forked stick, now often paired bent wires) or the changes in direction of a pendulum, supposedly in response to unseen influences. It is a type of divination used in attempt to locate underground water and buried objects, such as metals, minerals, ore deposits, precious stones, radioactive materials, grave sites, caves, ley lines and other infrastructures, archeological bodies, and even earthquakes' triggering sites, using special rods (bars or sticks) [1–3]. The rods used in the detection's process may be made of various materials, such as copper, iron, glass, plastic, or wood as being a good choice because wood is an isolator; thus acts as a non-conducting material.

The dowsing simple device used by a person (the detector who conducts the investigations) is commonly referred to as a dowsing or divining rod, although it may not be rod shaped. Traditionally, the most common method used is twig dowsing, which is a Y-shaped forked branch taken from a tree or shrub. The detector walks slowly over places where the target (for example, metals, minerals, underground water, archeological sites, etc.) is suspected, and the dowsing rod is expected to dip, tilt, or shiver upon detection of a substance or object searched.

Many detectors (dowsers) currently use a pair of L-shaped rods made of metal or wood. One rod is held in each hand, with the short arm standing upright, and the long arm pointing forward. The long arm is often free to rotate or move around, and when something is detected (or dowsed), the rods move synchronously. Depending on the target searched (or dowsed), the two rods may cross, oscillate, or take the 180-degrees' position. If the target is long and straight, such as a water pipe, for example, the two rods may point in opposite directions, indicating the target's direction.

Some researchers attributed the rods' movement to the kinesthetic phenomenon, as being a psychological kinesthetic sense [4–6]. Kinesics (also referred to as kinaesthesia or kinesthesia) is the perception of body movements and the detection of changes in the body's position and movements. On the other hand, perception refers to people's sensory of somethings that they experience, representing the process of using their senses to perceive objects and relationships. Through such experience, people gain information about the environment around them [7,8]. This means that the dowsing experimental technique – DET – can be explained as a psychological response where the person makes a movement unconsciously. According to these researchers, simply put, detector's rods respond to the user's accidental or involuntary movements and, therefore, DET is considered by some observes as "pseudoscience" [9,10]

Nevertheless, the dowsing phenomenon is a very old practice, which is widely documented and authenticated in the literature back to many centuries ago [11–17].

The practice of metal detecting with speculums (or dowsing) was popular in parts of Europe in the 15th century when it was considered by some to be a legitimate method for miners to find metal ores. One of the first recorded metallurgists/mineralogists, Martine de Bertereau (est. 1578–1589), was a mining engineer who lived and worked in France. She worked with her husband and used a variety of techniques and types of knowledge in her work, including metal detecting with speculums (dowsing), astrology, and botany.

In 1556 (about 470 years ago), "De Re Metallica," a book on metallurgy and mining written by Georgius Agricola, discussed dowsing as an acceptable method of locating natural resources, namely metals and minerals [11]. German miners used this technique – DET – as early as the 16th and 17th centuries, searching for zinc and silver mineral ores in mining locations in the UK [18,19].

In the late 1960s during the Vietnam War, US Marines used DET to locate weapons and tunnels [20]. As late as 1986, when 31 soldiers were caught in an avalanche during a NATO (North Atlantic Treaty Organization) exercise in Norway, the Norwegian military attempted to locate the soldiers buried in the avalanche, using DET as a search method [21]. Recently, some farmers and water engineers in the UK are still using the dowsing practice to search for underground water [22,23].

As early as the 1910s and 1920s, the issue of dowsing started to take interest and more attention of some research scientists, discussing DET's scientific dimensions, in terms of its implications and interpretations. In 1917, Ellis [24] made a comprehensive review of the previous investigations related to water dowsing over more than 4 centuries, which started from almost 1500 and ended in 1917. Ellis asserted the view that in the present state (then in 1917) of knowledge, any such claim is purely speculative.

Some British scientists conducted scientific work on dowsing and concluded that the results obtained were either a matter of chance or could be explained according to observations from Earth's surface evidence [25,26]. In 1936, the widely known scientific journal "Nature" published an article, indicating that there is nothing mysterious about the power of dowsing, and that is subjected to specific natural laws [27]. W.A. Macfadyen – a geologist – tested three DET detectors during 1943–1944 in Algeria (North Africa), which resulted in completely negative outcomes 92.

From the standpoint of natural sciences (physics, chemistry, geology, hydrology, and hydraulics), DET, using a forked twig, seems to be amazing [28]. In 1959, archaeologist M. Aitken tested the British dowser P.A. Raine, and found that Raine failed to survey the location of a buried furnace identified by a magnetometer [29].

Rocard [30] showed that the rods used in the dowsing practice responded to electromagnetic fields, as the dowsing's reaction occurs at individually different magnitudes of the magnetic field. Rocard concluded that the dowsing's reaction cannot depend on induced currents. In 1977, Wyman [31] wrote a book about using DET as being applied for water, minerals, metals, and oil exploration, and indicated that dowsing practice was successful in some cases. In 1978, physicists Balanovski and Taylor [32] reported a series of experiments which they conducted, looking for unusual electromagnetic fields emitted by dowsing objects; however they did not detect any.

Engh [33] reported about a field test in which the dowsing's reactions could not be correlated to magnetic anomalies. One explanation is that it could be a matter of frequency rather than amplitude of the magnetic field. Engh also reported that dowsing's reactions occurred when the dowsers walked over a hidden permanent magnet. In 1988, three British academics (Bailey, Cambridge, and Briggs) conducted DET on the grounds of various churches in the UK, and reported successful results presented in their book "Dowsing and Church Archeology" [34,35].

Nordell [36] simplified the dowsing's phenomenon (divining rod function) in the general idea that the body of the detector (the examiner or dowser) acts as the receiver, and the buried or hidden substance that needs to be searched or dowsed and uncovered acts as the transmitter. According to Nordell, it is unknown whether electromagnetic fields directly or indirectly cause the detector to react, meaning that it could be another field based on the electromagnetic field. The received signals trigger slight, involuntary muscle movements, which are amplified by the dowsing's rods. The forearms' bones of the investigator act as receptors for magnetic and electromagnetic field changes. This idea is based on the piezoelectric properties of bones, which can lead to involuntary muscle movements that cause the detector (dowser) reflex, which could be explained both mechanically and electrically. In 1998, Reddish [37] applied the interferometry technique, which is widely used in physics to study radiation fields, to investigate the metal detection process (or dowsing technique). Accordingly, Reddish indicated that the presence of patterns shows that the inference field was wave radiation. Since there was no detectable difference between the patterns produced by pairs of components made of good electrical conductors such as copper, and those produced by good insulators such as unplasticized polyvinyl chloride (uPVC), it was concluded that the radiation field was not electromagnetic.

Back in 1965 (approximately 60 years ago), scientists tried to use the dowsing technique in medicine. Dr. Liddle [38] reached an obvious experimental idea and wrote: "Researchers use solid wooden forks to locate water. But if we reversed the process, using a polyethylene tube filled with water, would it be possible that I would not be able to locate solid cancerous tumors buried in the human body? Before I applied for a research grant from the National Cancer Institute, I conducted a pilot study." Also, in medicine, McCarney et al. [39] conducted a medical study for which the participants used toxicology in clinical laboratories to elicit miasma or toxic load and find appropriate treatments or therapies, often for disorders where the cause cannot be determined. For this experiment they used DET, and concluded that the sample size was small, and the absence of evidence of an effect does not mean that there is no effect. However, the results should raise the question of whether toxicology in a clinical setting can produce objective information. If the technology (DET) proves effective in a clinical setting, this may suggest a subjective basis, where the technology elicits information that the clinician intuitively knows.

Piezoelectricity is physically defined as the electric charge that accumulates in certain solid materials—such as crystals, certain ceramics, and biological matter such as bones, DNA (Deoxyribonucleic Acid), and various proteins—in response to applied mechanical stress [40]. In the relaxed arm, the changes in the electromagnetic field cause only a small, imperceptible change in the bone size. In the strongly loaded arm of the detector (the person who conducts DET), the piezoelectric effect causes both mechanical stress and electrical potential. B. Nordell (1988) strongly believed that there is no doubt that "the dowsing's reaction is a physical reality," based on results of modern dowsing research.

Recently, some considerable research works have been carried out on DET and its implications and interpretations. Enright [41] conducted a comprehensive applied project in 1987–1988 to investigate whether water dowsers can detect water from a distance by extraordinary means. Funded by the German Government for DM (then the German currency Deutsche Mark) 400,000, the carefully planned research was conducted by university scientists from Munich, and involved nearly 10,000 tests, using about 500 dowsers. The results demonstrated that a real dowsing phenomenon exists, as certain individuals achieved remarkable success rates, apparently based on processes that present-day science cannot explain: an interpretation that has been widely publicized. Greenwooden and Price [42] provided an explanation of the dowsing's phenomenon in terms of electrostatic forces, as being associated with electromagnetic forces. Electrostatic forces are attractive or repulsive forces between particles that are caused by electric charges. This force is also called the Coulomb force or Coulomb interaction, and is so named for French physicist Charles-Augustin de Coulomb, who described the force in 1785 [43,44].

Dowsing experimental technique – DET – may be of a great value as a cost-effective and non-intrusive initial method for estimating the location of certain underground waters and void services prior to the use of geophysical exploration techniques. Deming [45] indicated that DET is a form of divination that uses a forked stick, rod, or pendulum to locate groundwater under the Earth's surface. Also, DET is a practice to predict the future through various natural or psychological techniques, as being recognized and practically used in all ancient, modern, primitive, and complex civilizations around the world.

Young and Trow [46] pointed out that the question arises whether the dowsing's response is related to any geophysical measurements, such as the intrinsic potential or the electromagnetic response. It was found that the rods easily moved in the detector's hands and, thus, the detector responded to the intrinsic potential and electromagnetic response. Janks [47] used DET and concluded that dowsing's rods move because of large changes in electrical conductivity of materials investigated, composed of highly conductive metals or highly resistive ceramics and plastics. Afonso and Gilbert [48] conducted an education study amongst university students and found that many students believed in the effectiveness of water dowsing, and provided pseudoscientific explanations for it. Furthermore, they pointed out that the students were unaware of the criteria for distinguishing between science and pseudoscience and, thus, designed further research studies to investigate water dowsing.

A study published in pathophysiology hypothesized that such dowsing's experiments conducted in the 20th century could be interfered with radio (electromagnetic) frequency radiations, as the radio waves were absorbed by the bodies of the test subjects, so that unconscious hand movement's reactions occurred afterwards, following the standing waves or intensity changes [49]. According to some scientists, dowsing was faced with skepticism, as a number of scholars attempted to explain the phallus' purported efficacy in a number of different ways, ranging from satanic arguments to the physics of atom theory [50].

Radford [51] questioned the following: If DET can be shown to work, what could the mechanism behind it, and how could a twig or two rods know what the detector is looking for (water, money, minerals, missing items, etc.), let alone where to find it? Radford claimed that the proposed mechanisms are as diverse as the detectors themselves. Some sources claim that powerful psychic energy is radiated from the body and detected by the detector, while others believe that ghosts, spirits, or mystical Earth energies guide the detector to their targets.

Wilcock [52] investigated the possible scientific justification of dowsing for the detection of caves, and concluded that the magnetic, electric, and electromagnetic fields are probably the most likely candidates behind caves' dowsing. More [53] presented four detection methods and explained how they are based on science. More [53] indicated that quantitative investigations of dowsing represent an area of active research. He further concluded that experiments conducted by scientists have shown that there is no effect of electric or magnetic field on the detectors. The only effect is a gravitational force on these devices impacts them. Today's impact detecting tools are featured and used by mineralogists, geologists, engineers, environmentalists, psychologists, and even militaries in various countries. Some dowsers were able to find water sources in "dry" California, USA, using copper divining rods with great accuracy [54]. One possible explanation is related to the physical interactions between the Earth's magnetism and the divining rods.

Studies have shown that there is a change in the magnetic gradient when water moves through the pores or fractures under the ground. Theoretically, if an object made of a material that is attracted or repelled by magnetic forces, such as copper prospecting rods, they (rods) should move when the magnetic force changes over groundwater under the Earth's surface. Dillinger [55] pointed out that the key to the enduring success of the divining rods is their simplicity and cheapness combined with essentially unlimited applicability.

Woolley [56] concluded that scientists of natural sciences need to get involved by working closely with scientists of social sciences. Focusing on the "supernatural beliefs" of some dowsers misses a deeper point that research reveals that dowsing is first and foremost a practice and not a belief. Woolley [56] analyzed the features of the controversy related to DET, in order to identify the underlying cultural attitudes towards knowledge and the landscapes it reveals. Woolley concluded with two notes of caution about the critical position adopted by scholars who are quick to condemn this customary practice, stressing the importance of understanding the nature of suppression as a cultural form regardless its efficacy, and the need for scholars to be aware of it and their prejudices and preconceptions.

Emerson [57] thought about the performance of geophysics applied to the first few tens of meters below the Earth's surface in environmental fields, including metallurgy (barrels and buried scrap), hydrogeological, unexploded ordnance, forensics, engineering, and mineralogical investigations through highly trained scientists and engineers, with the consideration that the near subsurface is a difficult medium, often having volatile lateral and vertical fluctuations. Some other researchers pointed out that DET is a reliable way to locate important underground items including water, oil, minerals, metals, and even graves, while others view the practice as controversial or even pseudoscience [58].

According to Bartol [59], "While the practice of dowsing has been formally discredited as pseudo-science, its use persists. My mother's family has long been regarded for their water-witching [dowsing] abilities." However, according to Bartol, the dowsing practices have been related to the white settlers since the 15th century, searching for water, minerals, and coal, as she said, "I was born in K'jipuktuk (Halifax, NS, [Nova Scotia, Canada]) and spent a good portion of my childhood there. For me, dowsing is a way to discuss my relationship with the Earth and my own complicated cultural and familial history. Through this work, I reflect on how I, along with other white settler Canadians, am implicated in systems of oppression—organized around white settler colonialism, white supremacy, patriarchy, and capitalism—intertwined with environmental degradation, Indigenous dispossession, and ongoing colonial violence." Bartol concluded her article with a philosophical question, "How can dowsing teach us to embrace uncertainty in ourselves? Can we learn to hold more than one answer in our minds?" Again, here is another example that shows the imminent interactions between applied, physical, natural sciences on the one hand, and psychology and other human sciences, on the other hand.

Approximately 120 years ago, Thilly [60] indicated that the introduction of laboratory methods into psychology has given it a scientific flavor, and experimentalists are often shy of the company they are obliged to keep. They have greater respect for the kind of work done by natural scientists who tend to smile at the claims of philosophers and, thus, are eager to join them. Or it is believed that psychology is itself a natural science and rightly belongs to this field. Therefore, mental processes cannot be understood without knowledge of their natural (physical, chemical, biological, geological, and environmental) aspects and perspectives and, hence, they must be dealt with, accordingly. Martin and Sugarman [61] pointed out that much of the current confusion surrounding explanation in science arises from the unjustified tendency of some commentators to treat explanation as subjective, in ways that ignore the objective basis of explanation within organized social practices, including scientific practices sanctioned by scientific communities. Some research scientists have tried recently to link the dowsing technique with the impacts of climate change and global warming and their resultants, such as droughts [62].

To conclude, the practice of dowsing experimental technique – DET – holds a history of mysticism, magic, and supernatural beliefs, as well as natural sciences' relationships, associated with the divine wand dating back over 8,000 years [63]. This part (Literature Review) of the present research paper can be best concluded by the Theoretical Physics' Scientist and Noble-Prize Laureate – Albert Einstein, as saying: "The intellect has little to do on the road to discovery. There comes a leap in consciousness, call it intuition or what you will, the solution comes to you and you don't know how or why. The truly valuable thing is the intuition" [64].

1.2. Literature review: Geophysical techniques

The current research connects multiple areas of knowledge and expertise, with respect to the dowsing experimental technique – DET. These include physics, chemistry, geophysics, geochemistry, mineralogy, ore deposits, mining, nanotechnology, and nanoscience, as well as psychology in attempt to serve all of these areas and explain the phenomenon of DET. In light of the reviewed examples of some recent publications in applied (exploratory) geophysics, in relation to mineral deposits (mentioned above), one can conclude that geophysical techniques still lead the scene in this highly beneficial industrial sector that cover ore deposits; mining; metallurgy; and mineral, water, and hydrocarbon exploration. Currently, geophysical techniques (various methods, instruments, acquisitions, processings, analytics, software, hardware, interpretations, etc.) proved to be highly effective in searching for metals, minerals, ore deposits, groundwater, hydrocarbons, radioactive materials, and conductive thermal materials, as well as in identifying, characterizing and analyzing aquifer and reservoir properties, buried objects, engineering, environmental, and military issues.

Geophysical techniques (GTs) have been around for a long period of time. They have enabled industries, militaries, research scientists, academicians, students, and so on to identify metals, minerals, ore deposits, and rocks, as well as fluids (such as underground waters and hydrocarbons), fluid leakages, buried objects (such as tunnels and pipes), buildings' foundations, etc. Such techniques include seismic (acoustic), using refraction and reflection methods of compressional (P) and shear (S) waves; electric; electromagnetic; gravity; magnetic; georadar; well-logging, remote sensing, and others. The literature has a plenty of examples on GTs and their applications in various areas of expertise and interest.

Following are a few examples of some recent publications on geophysical prospecting of groundwater, minerals, and ore deposits; some of which are also associated with DET. Dharmadhikari et al. [65] conducted a study to explore groundwater in some locations in India, for which they used DET as well as some GTs, including near-surface geophysical methods, such as semiconductor laser light box (SCLLB) and proton precession magnetometer (PPM), coupled with vertical electrical soundings (VES). They concluded that the application of the modern automated geophysical measurements, coupled with the ancient simple technology of groundwater dowsing – DET – showed the potential to create a database of groundwater resources at the national level, especially in hard rocks. They suggested that DET's detector may achieve the detection's reaction as a result of introducing magnetic field gradient changes caused by the groundwater investigated.

Pinet et al. [66] stated, "Geophysical methods have strong theoretical basis, data accuracy is now high enough for many applications, and processing and interpretation software are widely available. However, on one hand, geophysical interpretations remain associated with a doubtful reputation for many Earth scientists including some economic geologists. On the other hand, geophysicists often consider geology as an historical science that ignores physical principles."

In 2021, Zhdanov [67] edited a book entitled, "Special Issue Geophysics for Mineral Exploration," which was introduced as follows: "Exploration geophysics plays a major role in unlocking mineral reserves. It is well recognized that many easily discovered large mineral deposits with a strong geophysical signature have already been identified. Future discoveries present significant challenges, being located undercover, in remote areas, and with less prominent geophysical signals. The modern-day challenges of exploration require developing novel geophysical techniques, which improve exploration success and lead to new discoveries. This Special Issue contains ten papers which focus on emerging geophysical techniques for mineral exploration, novel modeling, and interpretation methods including joint inversions of multi physics data, and challenging case studies. The papers cover a wide range of mineral deposits, including banded iron formations, epithermal gold–silver–copper–iron–molybdenum deposits, iron-oxide–copper–gold deposits, and prospecting for groundwater resources." This edited book by Zhdanov [67] includes several recent papers focusing on geophysical techniques applied to prospecting of minerals and other natural resources.

EAGE [68] called for papers to be considered for publication in a special issue on geophysics and mineral exploration, as stated: "Guest editors of the Special Issue say that after two well-received editions in 2015 and 2020 they have observed more research and industry activity in the mineral-mining sector is helping to accelerate the energy transition. This is evident as governments push enormously with subsidies and more research possibilities. The catch is that alternative sources of energies require access to raw materials for generation, storage, and transportation. The mineral exploration industry continues to chase deep-seated deposits while making sure intermediate ones are also effectively explored using state-of-the-art technologies that are socially acceptable but also provide sufficient resolution for drilling programmes. As demand increases, the mining industry also faces increasing pressure to produce more raw materials in more difficult and challenging mining environments prone to seismicity and unknown geological structures."

EGU [69] published a comprehensive special issue which included several papers dealing with the mineral industry. EGU introduced their special issue by saying: "The rationale behind this proposal is to bring together a number of articles aimed at exploring the current state and future prospects of mineral exploration, from different perspectives (e.g. remote sensing, geochemistry, geology, geophysics, modelling, mineralogy, structural geology.) Mineral resources are used in larger quantities than ever before in history, and are the basis of our modern society. The safe and sustainable supply of mineral resources is fostering a demand for innovative actions to cover the foreseeable future industry and human demands. Exploration is the first step in the mineral resources cycle. On the one hand, most of the giant deposits at shallow depths have been already explored and mined out and the industry is moving towards deeper and more complex mineral systems, which brings significant exploration challenges. On the other hand, the exploration sector needs time-saving, cost-effective, and, particularly in Europe, environmentally friendly and socially acceptable techniques to ensure sustainable access to mineral resources."

Baranwal et al. [70] invited research scientists to submit papers to be considered for publication in their book, entitled, "Special Issue – Using Geophysical Inversion for Mineral Exploration: Methods and Applications," stating: "The shift to green technology enormously increases the global demand for critical commodities. This makes it necessary to improve nowadays mineral exploration techniques and strategies to both increase the success rate for finding new economic deposits and to exploit resources that were inaccessible in the past. To achieve this, many different types of geoscience data and information are combined in advanced multi-methodologically approaches to develop complex high-resolution exploration models in modern mineral exploration. Geophysical methods play a central role in such kind of exploration since they allow non-invasive systematic surveying, and often have a significant depth penetration. They provide insightful geological information as 2D [two dimensional] and 3D [three dimensional] physical models. Sometimes, geophysical anomalies are even directly sensitive to the target mineralization and can give information about the location, size, shape, and type of a deposit."

1.3. Dowsing experimental technique (DET): Intersection of psychology and technology

As already mentioned, the current research connects multiple areas of knowledge and expertise, with respect to the dowsing experimental technique – DET. These include physics, chemistry, geophysics, geochemistry, mineralogy, ore deposits, mining, nanotechnology, and nanoscience, as well as psychology in attempt to serve all of these areas and explain the phenomenon of DET.

This research addresses areas such as digital tools, artificial intelligence, human-technology interaction, and cyber-psychology, demonstrating how information and communication technologies (ICTs) can be integrated with these newly added fields of knowledge to advance human achievement in science, innovation, and technology, in order to drive development and human progress, and to serve the United Nations' Sustainable Development Goals (UNSDGs). However, it should be noted that this intervention requires further research, as we are still in the early stages of exploring these fields of knowledge.

Nature has equipped humans with physical and intuitive senses and sensors to gather information about their own environments as well as the ecological environments (atmosphere, biosphere, and geosphere) at large. However, intuitive sensing is still the natural "psychic" power for humans. There are many ways to tap into intuition to find unique path in life, but only one method can provide a clear answer to a specific question, namely visual inference. However, the question is: Is psychic influenced by digital tools and is there any relation between both areas? The answer is "yes, indeed."

Ligtenberg et al. [71] used a digital dowsing rod system (DDRS) within a framework of a location based service to explore the cultural heritage of a region in The Netherlands. DDRS consists of service oriented architecture, web-client, content management system, and mobile client based on smart phones and windows mobile technology. Inspired by the technology acceptance model, the perceived use, the perceived usefulness, and the perceived enjoyment were evaluated using questionnaires and detailed user logging. Despite a number of technical shortcomings, DDRS was positively valued by the testers.

Lawson and Crane [4] described an Introduction to Psychology (ItP), in which they demonstrated water detection using DET, as being designed to promote students' critical thinking. An instructor demonstrated that metal rods crossed over an uncovered cup containing water, but no one containing sugar. Student volunteers, who used the rods, also watched them cross over the cup of water, even after the water cup was covered and secretly replaced with the sugar cup. Five days later, students who watched the demonstration were: a) less convinced that the water detection was true, facilitated communication after reading the anecdotal evidence; and b) more likely to propose DET as an explanation for several related phenomena, compared to students in control sections of the ItP course.

The current generation of artificial intelligence (AI) relies on machine learning (ML), where a computer is fed a massive dataset (also known as big data) and programmed with mathematical rules to process the data and create a new version of it or synthetically new models. AI and ML theorists are divided into two camps: the hard problem camp, which believes that consciousness is a metaphysical phenomenon that emerges from complex systems like brains; and the soft problem camp, which believes that all you need is a system that points to itself, as if to say, "Here I am" [72].

Definitions of consciousness vary among scientists and philosophers, but it is usually described as self-awareness, sometimes with additional criteria such as the ability to reflect. Clearly for persons to be aware of themselves in space and time (as being the fourth dimension or spatio-temporal continuum), they need proprioception (the ability to perceive their bodies' location in the space around them. According to Samitier [73], artificial intelligence – AI – opens new horizons for subconscious healing when combined with ancient practices such as dowsing – DET. AI opens up vast possibilities for use in treating various types of blockages that negatively impact people's lives. It allows people to generate random texts or images, through which discover hidden aspects of a person's energy field—true clues to healing, can be discovered. This healing system works because everything external (the AI-generated image) is a reflection of what is within each person, their energy field; preferably called psychic energy. In the subtle realms, there is no outside and inside, but rather a unified field of energy and consciousness.

As related to human-technology interaction and its association with DET, Huttunen et al. [49] demonstrated that there may be a physical phenomenon linking human responses in field experiments, where test subjects walked or sat in a slow-moving car, with the windows covered, and a detection rod was recorded in their hands. The correlations between the test participants' reaction points inside the moving vehicle and those traveling along the same track were highly statistically significant. However, this correlation was not observed at all test sites or points. The distance between the test site or point and the radio tower and the angle of incidence of the transmitted electromagnetic radio wave may have influenced the results. Accordingly, Huttunen et al. [49] hypothesized that experiments conducted in the 20th century were influenced by artificial radio frequency radiation, particularly FM (frequency modulation) radio and television broadcasting, as the test participants' bodies absorbed the radio waves, and involuntary hand movements following stationary waves or changes in intensity occurred due to multipath propagation. This indicates that a strong relationship exists between physics, as a natural science, and psychology, as science of the human behavior and reaction.

Regarding cyber-psychology and cyber-technology, cyber-psychology is an interdisciplinary field that examines the impact of technology on human behavior and mental processes. This is accomplished by exploring online behavior, internet addiction, online identity, cyberbullying, virtual reality experiences, and human-computer interaction [74]. In other words, Cyber-psychology is referred to as Internet psychology, digital psychology, or web psychology, representing the field of psychology that studies how people use digital or electronic devices such as computers, mobile phones, laptops, etc. to interact with others and the emotional impact of these online interactions or use on the human brain [75].

In this case, as regarding to the dowsing experimental technique – DET, the mind transmits intention and relevant information to an information field, hypothesized to be part of the structure of the universe. For example, a detected object has a specific orientation and may be immersed under the ground surface by local gravity effect, electromagnetism filed, the rotation of the Earth on its axis, or the Sun. In theory, for material objects, communicating this information is easy because the relevant part of the information field is located at the center of the detected object, surrounds it, and creates it. For intangible detected (dowsed) objects, however, the information appears to be transmitted via standing waves to a "relevant" part of the information field [76].

Varvoglis and Berger [77] pointed out that dowsing is a technique for locating groundwater, minerals, and metals, typically used to sense information about materials or geological conditions. Although there is debate about whether this technique is a psychic ability or a physical sensitivity to weak electromagnetic fields, its potential usefulness is unquestionable. Peter Taylor (82 years old) has recently tried to introduce Google Earth to his dowsing endeavoring (or divination power) to scour the planet for water, rare stones, and precious metals in dome sites in the United Kingdom [78]. Once the pendulum (a DET technique that Mr. Taylor uses) has homed in on an area where a resource could be located, Mr. Taylor arranges a site visit and uses his rods to determine where to start digging or drilling.

1.4. Purpose and novelty of the current research, and problems and obstacles faced it

By researching and scrutinizing the results of the research presented in this paper, the main objective was to focus on the dowsing experimental technique – DET – as an effective tool in the exploration of minerals, metals, and other materials, as confirmed by many researchers as discussed above. The results of this research work indicate that the improvements and new developments can provide great additions to the traditional use of DET. As has been shown in the present research work, the new additions, represented in the installation of capsules containing powdered materials, gave it a special novelty. Thus, DET with its new additions can be considered as a successful approach and supporting tool alongside the various geophysical techniques used in mineral exploration, but not a substitute for any of them. Moreover, the explanations given for the results obtained are based on interactions between the natural sciences (such as physics and chemistry) and the science of human behavior and reactions, in terms of psychology of consciousness.

The innovation and progress of this current research, represented in the nine different groups of minerals, metals, and other materials, is reflected in the design and production of a detector that can detect practically in the field all the different substances with detection's ease and speed, as well as at cheap costs. This, in turn, helps in exploration's operations at the lowest possible costs, such as excavation work and conducting laboratory analyses of samples taken from the field, as well as the considerations of protecting the environment, taking into account the fact that DET is a very environmentally friendly technique, which helps towards achieving one or more of the UNSDGs.

It has been shown that DET, with its new developments as described in this research paper, will make progress towards the exploration of minerals, groundwater, and other underground materials, using wooden rods and capsules as demonstrated and implemented in this experimental work. The experiments and their results presented in this research paper show that the nine different groups of substances (metals, minerals, rocks, ore deposits, and other materials) are associated with some sort of energy. This could be different kinds of radiation, heat conduction, and/or electromagnetic field, which help detect the different substances, using DET.

Amongst the problems and obstacles faced, while conducting this applied research on the ground, were the following: 1) Lack of previous scientific literature that deals with similar research in both countries – Jordan and Palestine, as this research work is the first of its kind to be conducted in both countries, so that its publication will be a merit and great achievement; 2) Painstaking search for pure metals and minerals with the aim of using them in the manufacturing of baits (grafts); 3) Absence of wells (boreholes) to place examined samples in them, in order to measure the depth of target materials, and to know the extent of using the detector. This is except a single borehole used to implement parts of the experiment; and 4) Lack of funding.

This research paper 1) provides a professional forum for critical discussion of topics that are ignored or inadequately studied for various reasons in mainstream science; 2) promotes an improved understanding of the social and intellectual factors that limit the scope of scientific research; 3) covers a wide spectrum of topics of interest, from obvious anomalies in established disciplines to rogue phenomena that seem not to belong to an established discipline; and 4) presents philosophical issues about the relationship between various disciplines of research, development, interest, and education that include applied natural sciences (such as physics and geophysics; chemistry and geochemistry; mining, mineralogy, and materials science and engineering, etc.), and human's behavioral psychology.

2. Background: Earth's rocks and earth's crust; mineralization & metallization

2.1. Earth's rocks

To have an idea about the materials used in the experimental work – DET – presented in this research paper, a brief description of the various kinds of rocks and their origination and the major minerals within the rocks composing the Earth's crust is given in this section of the paper.

The Earth is made up of fluids and solids, whereas the fluids are mainly water, hydrocarbons (oil and gas), and magma – some of which are found on the surface of the Earth and some others found in the interior of the Earth. Meanwhile, the solids are mainly rocks, minerals, and metals, whereas the rocks are globally classified into three groups: igneous, metamorphic, and sedimentary, which differ in their properties, size of the composite particles, and the modes of their formation.

2.1.1. Igneous rocks

They are formed by the cooling of a superheated melted fluid – magma coming from the interior of the Earth at various depths. The asthenosphere, which lies just below the upper mantle, is the region below the lithosphere that is the main source of magma. Igneous rocks may form directly by cooling magma from the Earth's interior or by cooling lava from the Earth's surface. Since they constitute the Earth's crust that was originally formed, and because all other rocks were derived from them, the igneous rocks, known as the "parents of all rocks" or the "primary rocks," are the most abundant rocks in the Earth's crust. On the basis of their mode of occurrence, igneous rocks can be classified as intrusive and extrusive rocks. Intrusive rocks (such as granite, diorite, and gabbro) are formed when magma solidifies below the Earth's surface, whereas the rate of cooling below the Earth's surface is slow, leading to the formation of large crystals that compose the rocks. On the other hand, extrusive rocks (also called volcanic rocks, such as basalt, andesite, pumice, rhyolite, and tuff) are formed by cooling lava on the Earth's surface. Because lava cools so quickly on the Earth's surface, the minerals' crystals that make up extrusive (volcanic) rocks are fine in size.

2.1.2. Sedimentary rocks

They are formed by the successive natural processes of sediments' deposition, known as "sedimentation." These deposits may be the eroded debris from any pre-existing rocks which may be igneous, metamorphic, or older sedimentary rocks. The processes of sedimentation and successive formation of sedimentary rocks is known as "decomposition." Because of the successive sedimentation and decomposition processes, sedimentary rocks have stratified or layered structures; hence they are also called stratified or layered rocks. Depending on the method of formation, sedimentary rocks can be classified as: 1) Mechanically formed sedimentary rocks, which are formed by consolidation of sediments under excessive movement, pressure, and cementation, resulting in different rocks such as sandstone, shale, conglomerate, and breccia; 2) Organically/biologically formed sedimentary rocks, whereas the consolidation of organic matter derived from plants and animals forms this type of sedimentary rocks, resulting in rocks such as coal, chalk, and marl; and 3) Chemically formed sedimentary rocks, as they are formed through various chemical reactions, resulting in rocks such as gypsum, rock salt, limestone, and dolomite.

2.1.3. Metamorphic rocks

They are those rocks that went through the process of metamorphism that results in recrystallization and realignment of the composite materials within an original rock. Hence, these rocks are formed under the influence of high pressures and temperatures, resulting in volume and shape changes (such as color, hardness, structure, and texture), affecting the original rocks and sometimes their mineralogical constituents and their chemical composition. When a transformation occurs without any appreciable chemical changes, the transformation is described as "dynamic." If the transformation occurs due to the effect of heat, it is described as "thermal." When transformation occurs through the realignment process due to direct contact with hot magma, the transformation is described as "metamorphism." If the rocks undergo reorganization, due to the enormous pressures and temperatures, which may result from a tectonic shearing, the transformation is described as "regional metamorphism." Metamorphic rocks can be classified into foliated, such as slate, schist, and gneiss; and non-foliated, such as quartzite and marble, originated from sedimentary sandstones and limestones, respectively.

2.2. Earth's crust

The Earth is made up of three major layers: the crust, mantel, and core. While the Earth's crust, representing the outer part of the lithosphere, it is very significant to human-beings, as it is the place where humans live and from which they take access their materials to survive and develop. These materials include food, in addition to solids (chemical elements, metals, minerals, and rocks) and fluids (water and hydrocarbons: oil and natural gas). In the current research, work has been focused on the Earth's crust and its constituting materials of solids and fluids, as some of the Earth's crust metals, minerals, and rocks were investigated through the dowsing experimental technique – DET, as explained below.

The Earth is made up of different types of chemical elements, whereas approximately 98% of the total crust is composed of 8 elements, namely: oxygen (O2), silicon (Si), aluminum (Al), iron (Fe), calcium (Ca), sodium (Na), potassium (K), and magnesium (Mg). The rest (2%) is made up of elements such as titanium (Ti), hydrogen (H2), phosphorus (P), manganese (Mn), sulfur (S), carbon (C), and nickel (Ni), as well as some other rare (or trace) elements. Table 1 shows the percentage share of each of the composing elements found in the Earth's crust and in the Earth entirely.

Table 1. The main elements and their percentage shares in both the Earth's crust and the entire Earth ([79,80]

Earth's Crust		Entire Earth	
Element	Percentage Share (%)	Element	Percentage Share (%)
Oxygen (O_2)	47	Iron (Fe)	35
Silicon (Si)	28	Oxygen (O_2)	30
Aluminum (Al)	8	Silicon (Si)	15
Iron (Fe)	5	Magnesium (Mg)	13
Magnesium (Mg)	4	Nickel (Ni)	2
Calcium (Ca)	2	Sulphur (S)	2
Potassium (K)	2	Calcium (Ca)	1
Sodium (Na)	2	Aluminum (Al)	1
Others	2	Others	1

These different elements (Table 1) are rarely found exclusively in the Earth's crust but they are usually combined with other elements to make different materials recognized as minerals. A mineral is composed of two or more elements, but sometimes single-element minerals, such as sulfur (S), copper (Cu), silver (Ag), gold (Au), graphite (C), etc., are also found. A mineral, a naturally occurring substance having an atomic structure and specific chemical composition, is characterized by specific physical and chemical properties.

The primary source of all minerals is the hot magma in the Earth's interior; as well as the sea. When the magma cools down, crystals of minerals appear and a regular series of minerals are formed in sequence to solidify, in order to form the rocks originated from magma. Minerals, such as calcite and aragonite ($CaCO_3$) and dolomite ($CaMg(CO_3)_2$), with different crystal forms, originated in the sea before the sea-rising, and are found in rocks such as carbonates, including limestones, dolomites, and marls. The minerals that contain metals are called metallic minerals, such as iron metals, including hematite (Fe_2O_3), magnetite (Fe_3O_4), goethite (FeO(OH)(, and limonite ($FeO(OH)_nH_2O$). The metallic minerals, existing in nature as ore deposits, are profitably mined.

Mineralogists have identified more than 5,000 minerals; of these less than 200 are common, and less than 50 are common enough to be considered essential minerals [81]. However, only 6 minerals are the most abundant and contribute the maximum, whereas abundance of oxygen (O_2) and silicon (Si) that make together up nearly three-quarters of the Earth's crust, naturally leads to abundance of silicate minerals.

The six most abundant minerals are feldspars, quartz, pyroxenes, amphiboles, micas, and olivine. Feldspars, having very comparable structures, chemical compositions, and bodily properties, consist of orthoclase ($KAlSi_3O_8$) and plagioclase that is divided into albite ($NaAlSi_3O_8$), and anorthite ($CaAl_2Si_2O_8$).

Quartz is a hard, crystalline mineral composed of silica or silicon dioxide (SiO_2). Pyroxenes, forming about 10–11% of the Earth crust's constituents, have the general formula $XY(Si,Al)_2O_6$, where X represents calcium (Ca), sodium (Na), iron (Fe) or magnesium (Mg), and more rarely zinc (Zn), manganese (Mn), or lithium (Li). Meanwhile, Y represents ions of smaller size, such as chromium (Cr), aluminum (Al), cobalt (Co), scandium (Sc), titanium (Ti), vanadium (V), or even iron (Fe^{2+} or Fe^{3+}).

Amphiboles, forming about 5–7% of the Earth crust's constituents, are a group of silicate minerals that are mostly found in metamorphic rocks and some igneous rocks, with the chemical composition of $NaCa_2(Mg,Fe,Al)_5(Al,Si)_8O_{22}(OH)_2$. Micas, forming about 4–5% of the Earth crust's constituents, appear in nature with different forms and chemical compositions. However, the most known varieties of mica that are commercially important are muscovite ($KAl_2[AlSi_3O_{10}](OH)_2K(Mg, Fe^{2+})(Al, Fe^{3+})[Si_4O_{10}](OH)_2$), bentonite ($Al_2H_2Na_2O_{13}Si$), and phlogopite ($K_2Mg_6(Si_6Al_2O_{20})(OH)_4$). Olivine, or high-pressure structural variants, constitutes over 50% of the Earth's upper mantle, making it one of the Earth's most common minerals by volume, having the chemical composition of ($(Mg,Fe)_2SiO_4$).

In view of the above, crust describes the outermost shell of the Earth. The Earth's thin, 40-km deep crust—just 1% of the Earth's mass—contains all known life in the universe. The Earth's crust, known as "oceanic crust," is mostly composed of different types of dark mafic rocks – basalts. Earth scientists often refer to the rocks of the oceanic crust as "SIMA," which stands for silicate and magnesium that represent the most abundant minerals in the oceanic crust. The other part of the Earth's crust is the "continental crust" which is mostly composed of different types of granites. Earth scientists often refer to the rocks of the continental crust as "SIAL," which stands for silicate and aluminum that represent the most abundant minerals in the continental crust. The continental crust – SIAL – can be much thicker than the oceanic crust – SIMA, as SIAL can reach a thickness of 70 km, but also slightly less dense (about 2.7 gm/cm^3) than the oceanic crust which has a density of 3.0 gm/cm^3.

2.3. Mineralization and metallization of ore deposits

From an engineering geology perspective, the term "mineralization" is the process that involves the chemical alteration, replacement, and enrichment of minerals within igneous, metamorphic, and sedimentary rocks. Replacement is the process by which one component of a system is gradually replaced by another through chemical alteration, replacement, and mineral enrichment [82].

In the sciences of physical geology, mineralogy, and crystallography, the aspect of "mineralization" is the process of precipitation of minerals and metals in the form of ore bodies that have economic importance. The term "mineralization" can also refer to the processes by which waterborne minerals are formed, such as iron oxides (hematite, limonite, and goethite), calcium carbonate (calcite, aragonite, and dolomite), silica (quartz), or other minerals, whereas minerals can replace organic matter within the body of an organism that has died and been buried by sediments [83]. The process of "mineralization" may also introduce minerals (such as iron) into the rock, which may then be referred to as "containing-iron mineralization."

The process of "mineralization" occurs in: 1) Veins, voids, tubes, stocks, and skeletal reefs [63,84,85]; 2) The form of diffusion and concentration of minerals in porous and fractured host rocks by deep groundwater circulation and hydrothermal activities [86]; 3) The form of metal concentration in unconsolidated sediments by the process of evaporation [87], weathering, erosion, deposition, and precipitation [88]; 4) Through the replacement of organic materials with inorganic materials, leading to fossilization [89], which is known as "bio-mineralization," where the material changes from organic to inorganic, and thus mineralizes; and 5) Soil science, where mineralization is used to describe the release of organic compounds during decomposition [90].

There are several factors and conditions that affect the mineralization and metallization processes. These include, but are not limited to: 1) Regional magmatism and tectonism; 2) Structural elements; 3) Sedimentary settings and deposition; 4) Climatic conditions; 5) Temperatures and pressures; 6) Depth of crystallization and mineralization processes; 7) Geogenic and anthropogenic patterns and environmental impacts; and 8) Concentration of ore deposits available for exploration. These factors and conditions are discussed below in further details.

1. Regional magmatism and regional tectonism

This factor has regional impacts on many issues, including ore deposits and their mineralization and metallization processes [91]. Koide [92] noted that ore deposits are produced from magma as well as regional geological tectonics. Thus, the following types of veins and ruptures are recognized in several regions of Japan: a) Fractures or ruptures associated with magma's seeps or intrusions; b) Fractures or ruptures associated with tectonics, such as land subsidence; c) Joints in or around igneous rocks caused by magma's solidification; and d) Fractures resulting from seismic activities, such as natural earthquakes or man-made explosions, generating seismic compressional (P) and shear (S) waves.

Accordingly, early fracturing, resulting from regional tectonics and/or seismic events, and subsequent hydrothermal mineralization, are treated as events not genetically linked to the occurrence of ore deposits. For porphyry and epithermal copper (Cu), deposits of massive volcanic sulphides, orogenic gold, Fe-Cu-Au oxides, anorthosite Fe-Ti oxides, and base metal deposits are widely found in Europe with ages ranging from Archaean (4–2.5 billion years ago) to the Neogene (23–2.6 million years ago) [93]. Most of these metals and minerals were formed during short-lived magmatic events in a wide range of tectonic environments; many of which can be related to specific tectonic processes, such as subduction, hinge retreat, island arc accretion, continental collision, and so forth.

2. Structural elements

These include faults, fractures, fissures, cracks, veins, shear zones, etc. The question is: Do such structural and geological elements have a direct impact on the ore deposits and their formation, and on the mineralization processes of metals, minerals, etc.? The easy and direct answer is 'yes.' Newhouse [94] pointed out that all those who deal with ore deposits (metals and minerals) know that there is a strong relationship between their presence and the structural elements and, therefore, they must follow them when prospecting for minerals and metals that have crystallized and mineralized.

Thus, these structural elements and their mechanical properties are of fundamental importance when searching for ore deposits, as they are amongst the leading features that have controlled the occurrence of ore deposits, as well as their extended existence. For example, in the presence of minerals and metals in high seated-shear zones, mineralization occurs by replacement [95]. Meanwhile, in the superficial areas the veins are infills and, therefore, specific minerals are found in narrow belts. On the other hand, the composition of fluids in the mineralization area can help determine the type of ore and find out whether the ore has been altered by chemical reactions or not.

Chauvet [96] studied the key role that pre-existing geological structures play in the formation of vein-shaped mineral deposits, and provided several examples, including gold deposits in Brazil, and shear zones and delamination structures that control the formation of gold veins through three distinct processes: 1) Reopening and reuse of shear zones in the case of gold mines in southern Peru; 2) Remobilization of the mineral into massive volcanic-hosted sulphide deposits by subsequent tectonic events and formation of a secondary reserve controlled by structures created during this event, as in the case of pyrite deposits in Spain; and 3) Economic stock formation by comparing deformation behaviors between ductile black schist versus more efficient brittle dolomite, such as the copper deposits in Morocco. These examples in Spain and Morocco include changing the rheological efficiencies within zones affected by deformation and/or alteration [97], in order to reach the stage of mature mineralization. Regarding the case of Spain, the importance of magmatic and hydrothermal metamorphism in the formation of mesothermal gold deposits was emphasized. These examples, provided by Chauvet [96], clearly illustrate the crucial role played by pre-formed structures and/or fabrics (textures) in the development of ore deposits' metallization and mineralization processes.

3. Sedimentary settings and deposition

These include erosion, weathering, alteration, orientation, dissolution, precipitation, cementation, lithification, lamination, stratification, crystallization, and mineralization, considering the fact that sedimentary rocks form on or near the Earth's surface, unlike igneous and metamorphic rocks that formed deep within the interior of the Earth. The most important geological processes that lead to the formation of sedimentary rocks are erosion, weathering, dissolution, precipitation, cementation, and lithification.

Erosion and weathering involve the effects of wind and rain, which slowly break down large rocks into smaller rocks and stones. Erosion and weathering transform rocks and even mountains into sediments, such as sands and clays. Dissolution is a form of weathering (chemical weathering), through which slightly acidic water slowly erodes stones. These three processes (erosion, weathering, and dissolution) create the raw materials for new sedimentary rocks and even mineralization.

Precipitation, cementation, and lithification are processes that lead to the construction of new rocks or minerals. Precipitation is the formation of rocks and minerals from chemicals that precipitate from water. For example, when a lake dries up over thousands of years, it leaves behind mineral deposits, similar to the case of evaporite minerals that have formed in the Dead Sea region, Palestine and Jordan [98]. Layering (macro-stratification) and lamination (micro-stratification) are major features characterizing sedimentary rocks and, therefore, have an important role in mineralization and metallization processes. These micro- and macro-stratifications in sedimentary rocks lead to homogeneity or heterogeneity which result in anisotropy of electric current conduction, hydraulic flow, and seismic wave propagation through rocks and sediments [99], which (anisotropy) affects mineralization and metallization processes. Meanwhile, cementation is the process of cementing, coupling, or liking the composite grains of minerals with each other through chemical processes through long periods of the geological times.

In addition, these features have significant effects on the physical and chemical behavior of sedimentary rocks and their saturating fluids (e.g. [99–102]. Briefly, mineral and metallic ores in sedimentary rocks can occur or evolve through various processes, including chemical diagenesis in clastic rocks (for example, mineral sulfide deposits in sandstone); deposition in chemical sedimentary rocks (for example, salt evaporite deposits or gypsum); and the accumulation of organic matter in organic sedimentary rocks (for example, bog iron ores in peat bogs) [103]. These processes lead to the formation of economically viable mineral concentrations in various types of sedimentary rocks.

4. Climatic conditions

This factor mainly includes rainfall (or precipitation), humidity, and evaporation. The location of ore deposition and the amount of ore are affected by these climatic conditions. For example, increased rainfall will cause more chemical reactions to occur between ore deposits and other influencing agents. This is because rain flows through the ore channels and, thus, affects its quality and quantity, as well as the possibility of replacing it with other types of ore deposits due to chemical reactions.

These processes regulate the amount of fluids that pass through each channel of the ore deposit, while the mineralization solutions also act as metallization agents. This explains the importance of the roughness (or coarseness) of cracks or veins filled with ore deposits, and why the effective openings for metasomatic replacement lie within a narrow range of capillary size [94]. Metasomatic replacement is the way in which wood fossilizes (silica replaces wood fibers), one mineral forms a pseudomorph of another, or one ore deposit replaces an equal volume of another ore deposit or rock.

Increased humidity, atmospheric pressure, temperature, and soil moisture also affect the formation of minerals, and sometimes their alteration and replacement. Guntiñas et al. [104] pointed out that climate change, which includes changes in climatic factors, such as temperature and soil moisture, affects the mineralization of organic matter and the cycling of biophilic elements, such as nitrogen.

5. Temperature and pressure

Hydrothermal solutions under temperature and pressure are responsible for fracturing and then successive mineralization processes [92]. Ore-forming chemical elements, such as copper (Cu), molybdenum (Mo), and gold (Au), along with the presence of hydrothermal fluids needed to form porphyry copper deposits, are separated and deposited from felsic magma during the cooling and crystallization processes, due to physical and chemical changes.

The cooling and crystallization processes of magma are affected by various factors, which mainly include the initial cooling temperature of magma, the initiation speed of the magma chamber inherited from deep-seated magma pulses, and the cooling rate resulting from the contact between the magma chamber and the surrounding rock [105]. Amongst the common silicate minerals is olivine, which usually crystallizes first at a temperature between 1200°C and 1300°C. As the temperature decreases, and assuming some silica remains in the magma, the olivine crystals react (fuse) with some of the silica in the magma to form pyroxene. As long as there is residual silica and the cooling rate is slow, this process continues and, thus, olivine changes to pyroxene which, in turn, reacts with amphibole, and amphibole with biotite. Finally, if the magma is rich enough in silica, some will still remain at a temperature of about 750–800°C, and from this last magma potassium feldspar, quartz, and perhaps muscovite mica will form (Figure 1).

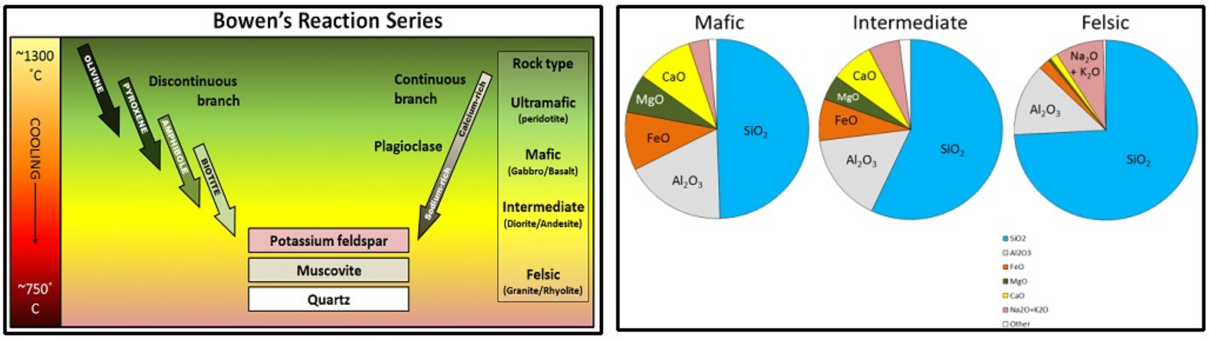

Figure 1. Left: The Bowen reaction series, representing the process of magma crystallization; Right: The chemical composition of typical mafic, intermediate, and felsic magmas and the types of rocks that compose them ([109])

Regarding the effect of pressure on the mineralization process, Xiong and Kreuzer [106] pointed out that the behavior and development path of hydrofracture, which shows a close relationship with the process of hydrothermal mineralization, is greatly affected by fluid flow and fluid pressure. Their results indicate that the way fluid pressure develops is a key factor for measuring the behavior of the hydrofracturing and mineralization processes. In their model, Xiong et al. [107] found that fluid pressure can rise to a rock failure state, which is set as rock pressure at a depth of 10 km (270 MPa), either due to porosity reduction or dehydration reactions. Rapid pressure drops, resulting from fault rupture or local hydrofracturing, may lead to the processes of repeated precipitation and gold mineralization.

6. Depth of crystallization and mineralization

Depth has a significant impact on the crystallization, metallization, and mineralization processes. Kan et al. [108] studied the crystallization of biotite phenocrysts at depths ranging from 6.0 to 12.9 km. They found that the magma responsible for the formation of biotite ore is highly oxidized, but it also possesses a magma chamber located at a great depth within the upper crust, allowing a wide depth for melting processes. Furthermore, partial thermal analysis of fluid inclusions revealed that a portion of the fluid undergoes significant conductive cooling as it rises along the channel, due to the depth of fluid decomposition. This process causes the raw fluids to remain in the liquid zone only without boiling, which helps to enrich and mineralize the materials to be crystallized. This means that the depth of fluid dissolution plays a crucial role in determining the mineral grades and economic value of porphyry deposits, by regulating the evolution path of ore fluids.

7. Geogenic and anthropogenic patterns and environmental impacts

Meng et al. [110] investigated different levels of geogenic and anthropogenic (geological and human) controls on three metals: aluminum (Al), calcium (Ca), and lead (Pb) in urban topsoil in the Greater London Authority (GLA) area, London, UK. These three mineral-composing elements clearly showed different spatial distribution influenced by human activities. They found that: 1) High values of Al are present in the clays that exist in the northern and southern areas of GLA; 2) Lead (Pb) accumulates in built-up areas and near traffic roads, likely related to leaded paint and leaded gasoline; 3) High calcium (Ca) concentrations were found in the chalk bedrock of the southern GLA and the historic dismantling and reconstruction sites in the city center.

Meng, Cave and Zhang [110] study revealed different levels of geogenic and anthropogenic controls on different chemicals in urban soils. For example, while the spatial distribution of Pb, which is more easily affected by human activities, can change significantly, the inactive element aluminum (Al) may still be able to maintain its normal distribution. Meanwhile, calcium (Ca) shows a mixed spatial distribution influenced by natural factors and human activities.

Soltani-Gerdefaramarzi, Ghasemi and Ghanbarian [111] examined the pollution effects of heavy metals present in urban soils in Yazd, Iran. For that purpose, 30 surface soil samples (0–10 cm deep) were collected from Yazd within an area of approximately 136 km^2 with a population of approximately 656,000, where the concentration of heavy metals was measured. They found that arsenic (As), cadmium (Cd), lead (Pb), and zinc (Zn) were affected by anthropogenic sources. Meanwhile, concentrations of iron (Fe), manganese (Mn), nickel (Ni), chromium (Cr), cobalt (Co), copper (Cu), and cesium (Cs) were generated mostly from natural geological sources. They also found that cadmium (Cd) and lead (Pb) have been found to be very rich in the area, while at the same time other heavy elements show minimal enrichment.

However, the degree of environmental risk varies for the different metals investigated, as some showed low to moderate levels of risk, while others showed high levels. For example, lead (Pb) was found to exhibit a moderate environmental risk level of 39%, while cadmium (Cd) and arsenic (As) showed a contribution to environmental risk of 72% and 100%, respectively. According to the results of their study, Soltani-Gerdefaramarzi, Ghasemi and Ghanbarian [111] found that the investigated area is at a very high environmental risk level and, therefore, sound management practices are necessary to reduce pollution resulting from the heavy metals present in the topsoil of the area, by both effects: geogenic and anthropogenic.

8) Concentration of ore deposits available for exploration: A mineral deposit is a mass of rock in which one or more minerals have been concentrated or deposited to the point where they can be economically extracted. Some basic levels of important minerals can be found in nature at typical levels or concentrations required to form viable deposits, and corresponding concentration factors. Searching for copper (Cu), for example, while the average rock contains about 40 parts per million (ppm) of copper, a grade of about 10,000 ppm or 1% is necessary to create a viable copper deposit [112].

In other words, copper ore contains about 250 times the copper found in traditional rocks. For other elements, the concentration factors are much higher. For example, it is about 2,000 times for gold, and about 10,000 times for silver [112] (Table 2). Obviously, a very large concentration must occur to form a mineable deposit. This concentration may occur during the formation of the host rock, or after its formation, which can happen through a number of different types of processes.

Table 2. Typical background and ore levels of some important metals ([112])

Metal	Typical Background Level (in ppm)	Typical Economic Grade (in ppp)	Typical Economic Grade (in %)	Concentration Factor (How many times)
Copper (Cu)	40	10,000	1	250
Gold (Au)	0.003	6	0.006	2,000
Lead (Pb)	10	50,000	5	5,000
Molybdenum (Mo)	1	1,000	0.1	1,000
Nickel (Ni)	25	20,000	2	800
Silver (Ag)	0.1	1,000	0.1	10,000
Uranium (U)	2	10,000	1	5,000
Zinc (Zn)	50	50,000	5	1,000

There is a very wide range of ore formation processes, and there are hundreds of types of mineral deposits. It is important to note that the economic viability of any deposit depends on a wide range of factors. These include the deposit's grade, size, shape, depth below the surface, proximity to infrastructure, current price in the market, labor, environmental regulations in the region, and many other factors.

3. Materials' characterization

3.1. Radiation of materials

Radiation is energy that travels from one place to another in the form of rays, waves, or particles and, thus, people are frequently exposed to radiation in their daily life. Some of the most common sources of radiation include the sun, microwave ovens in kitchens, and many technological tools and devices that people widely use these days. However, some of these radiations pose no danger to public health, and some others certainly do. In general, radiations have lower risks at lower doses, but they can be associated with higher risks at higher doses. Depending on the type of radiation, different measures must be taken to protect human body and the environment from radiations' effects, while allowing communities to benefit from the many applications of radiations.

There are two types of radiation: non-ionizing radiation and ionizing radiation (Figure 2). Non-ionizing radiation is gadget radiation, such as the radiation emitted from mobile phones, laptops, desktops, tablets, smart TVs, Wi-Fi routers, network boosters, etc.

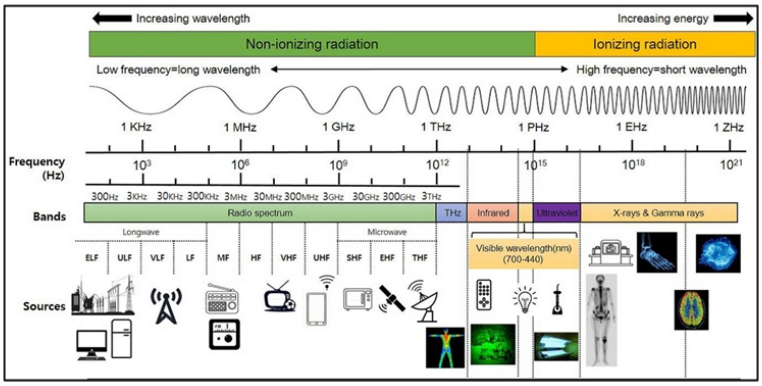

Figure 2. Non-ionizing and ionizing radiations showing different wavelength in meters, which are directly related to their released energies ([113–115])

Non-ionizing radiation (NIR) is a form of radiation with lower energy than ionizing radiation (IR). NIR refers to any type of electromagnetic radiation that does not carry enough energy per quantum to ionize atoms or molecules—that is, to completely remove an electron from an atom or molecule. NIR, though a low-frequency radiation, can form, to a certain extent, a threat to public health. On the other hand, IR (such as X-ray and gamma ray) is a high-frequency radiation that is known to cause many defects and problems to human's body. For example, radiations from the mobile-phone's towers, existing around homes, workplaces, markets, mosques, churches, and other public places, are harmful. In recent years, there has been growing concern about exposure to electromagnetic radiations emitted by cell phones and base-station antennas or towers.

Cell-phone towers contain wireless antennas that emit non-ionizing radio frequency radiation. When these antennas are located close to people's homes and schools, their daily exposure to radio frequency radiation intensifies. Mobile-phone towers within the range of 400 m can cause adverse impacts on human health [116]. According to Arya [117] (a medical doctor in oncology), cell phone towers and their radiation exposure are often associated with an increased risk of cancer and other health problems. Although there is little evidence to support this theory, there are reports suggesting a possible link. Radio frequency radiation is considered as a new form of "environmental pollution," besides air, water, soil, and noise pollutions. It may become a cause of health problems, such as cancers in the form of brain tumors and others when human's body is exposed to it for long periods of time [118]. The International Agency for Research on Cancer (IARC) has classified radiofrequency fields as "carcinogenic to humans," based on limited evidence highlighting a possible increased risk of brain tumors among cell phone users [117].

Several studies have confirmed concerns that living near base stations increases the risk of several health problems and defects (e.g., [114,115,118–124]). Effects of radio frequency radiation, documented in scientific research, include increased risks of headaches, dizziness, depression, memory impairment, sleeping disorders, cellular stress, genetic damage, reproductive system changes, effects on the nervous system, and even cancers. Research has found that the cumulative dose of radio frequency radiation from cell-phone towers can lead to significant exposure over time. Young children do not use cell phones, yet they are exposed to them involuntarily. Exposure to cell-phone towers' radiation is continuous day and night. As a matter of fact, we can turn off our cell phones, but we cannot turn off the cell-phone towers installed on top of buildings everywhere.

For example, according to Wolf and Wolf [124], a comparison of relative risks showed that the number of cases in areas that have mobile towers is 4.15 times greater than the number of cases in the general population. The study suggests a relationship between increased cancer incidence and living near a mobile phone base station. Balmori [121] reviewed 38 well-established and peer-reviewed published studies conducted in real urban settings, with mobile phone base stations located close to apartments. The overall results of Balmori's [121] analysis study revealed three types of health effects of telecommunications base stations or radiation towers: These include radiofrequency diseases (RFDs), cancers, and changes in biochemical parameters. Considering all studies reviewed globally (n = 38), 73.6% showed different effects distributed as follows: 73.9% for RFDs, 76.9% for cancers, and 75.0% for changes in biochemical parameters.

The components of atoms, chemicals, and different materials emit IR of different types. These include four main types of radiation, which are alpha ray, beta ray, neutrons' ray, and electromagnetic waves, namely X-ray and gamma ray. These different kinds of radiation differ in mass, energy, and the way they penetrate human body and other things. The first is the alpha particles, which consist of two protons and two neutrons, and are the heaviest type of radiation particles. Many radioactive materials, occurring naturally on the surface of the Earth (such as uranium (U) and thorium (Th)), emit alpha radiation.

An example that most people are familiar with its radiation is radon (Rn) in homes. Radon is an inert, colorless, odorless, and radioactive gas, which naturally occurs and can cause lung cancer. Radon is the number one cause of lung cancer amongst non-smokers [125,126]. Overall, radon is the second leading cause of lung cancer, as it is responsible for about 21,000 lung cancer deaths each year in the USA alone, whereas about 2,900 deaths occur amongst people who have never smoked [125]. Radon is naturally present in the atmosphere in trace amounts. However, most exposure to radon occurs inside homes and general places, such as workplaces, schools, mosques, and churches, especially if such places are old buildings. The question is: why do such places have high levels of radon's concentration? Radon becomes trapped indoors after it enters buildings through cracks and other holes in buildings. Once radon is emitted into the soil, it rises towards buildings' foundations. If there are any holes or cracks in the foundations, radon will inevitably seep inside [125]. The good news about radon is that it disperses quickly. However, indoor radon can be controlled and managed with proven and cost-effective techniques [127].

The second type of radiation is the beta rays or particles. They are represented in an electron that is not attached to an atom. Beta particles or rays have a small mass and a negative charge. Tritium (T or H_3 – the isotope of hydrogen – H), which is produced by cosmic radiation in the atmosphere and is present all around us, emits beta radiation. Carbon-14 (C-14), used for carbon dating of fossils and other artifacts, emits also beta particles. Carbon's dating simply relies on the fact that C-14 is radioactive. If beta particles are measured, they can tell how much C-14 is left in the fossil, allowing one to calculate how long the organism has been alive. The third type is radiation of the neutron rays or particles that have no charge and are found in the nucleus of an atom of a material. Neutrons are commonly seen when uranium (U) atoms split or cleavage in a nuclear reactor. If they are not for the neutrons, it is not possible to sustain the nuclear reaction used to generate energy.

The last type of radiation is the electromagnetic radiation, such as X-ray and gamma ray. Electromagnetic radiations of both X and gamma rays have short wavelengths and high photon energies (Figure 3) that can catalyze chemical reactions by forming ions and free radicals in radioactive materials [128].

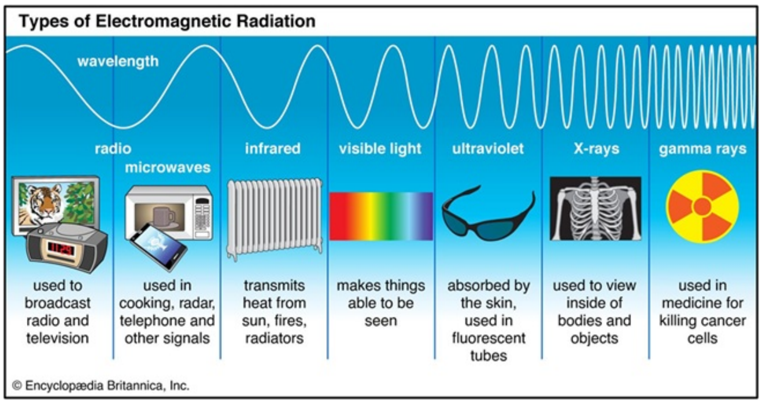

Figure 3. Types of electromagnetic radiation ([129])

Electromagnetic radiation is an electric and magnetic disturbance traveling through space at the speed of light (i.e., 2.998 x 108m/s). Unlike other types of radiations, it contains neither mass nor charge but travels in packets of radiant energy called photons or quanta [130]. They are probably the most common type of radiations, because they are widely used in medical treatments. These rays are similar to sunlight, except they have more energy. The amount of energy can range from very low, as in dental X-ray, to very high levels that seen in radiators used to sterilize medical equipment.

Figure 4 shows that different types of ionizing radiation – IR – can be distinguished by their depth of penetration, depending on their mass and energy.

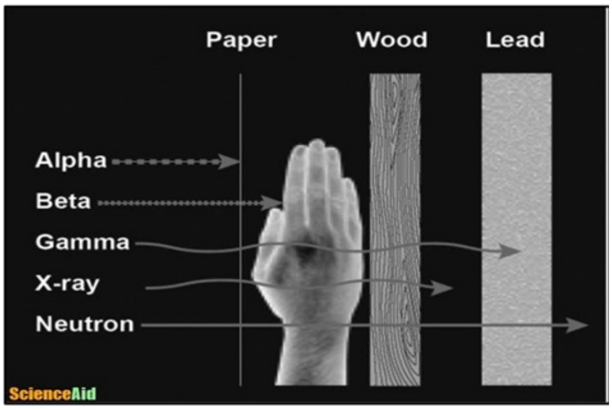

Figure 4. Demonstration of ionizing radiation ([132,133])

As shown in Figure 4, alpha and beta rays or particles have the lowest penetration rates, while neutron and gamma rays are able to penetrate materials down to lead metal (Pb), as being used in medical treatments. Neutron particles, since they do not have any charge, do not interact with matter very well and, thus, their radiation goes a long way (Figure 4). The only way to stop them is with large amounts of water or other substances composed of very light atoms [131].

Meanwhile, alpha particles, because they are very heavy and have very large charges, do not go far at all. This means that they cannot penetrate a sheet of paper (Figure 4). Accordingly, the alpha particles outside of human's body are unable even to penetrate the surface of the skin. But if one breathes in or ingest a substance that emits alpha particles, delicate tissues like the lungs can be exposed and possibly affected by it in a negative manner. This is why high levels of radon are such a problem in homes (as discussed above). Being able to stop alpha particles so easily is useful in smoke detectors, because a little smoke in the room is enough to stop an alpha particle and trigger an alarm [131].

Beta particles go a little further than alpha particles (Figure 4); therefore one can use a relatively small amount of protection to prevent it. Beta particles can reach the human's body but they cannot go any further. To be useful in medical imaging, beta particles must be released by a substance injected into the body. They can also be very useful in treating cancer if radiologists can put the radioactive material directly into a tumor. Beta-emitting radioisotopes have been shown to inhibit the proliferation of cancer cells by inducing cell death and halting the cell cycle [134].

X-ray and gamma ray, on the other hand, can easily penetrate human's body (Figure 4). This is why they are useful in medical treatments, as they can show if a bone is broken, where tooth decay is, and to locate a tumor, for instance. Shielding with dense materials, such as concrete or lead (Pb), is used to avoid exposing sensitive internal organs or people who work with this type of risky, dangerous radiation. For example, the technician, who does the X-ray of teeth, should put a lead apron over the patient before taking the picture. This apron prevents X-ray from reaching the rest of the body. The technician stands behind a wall, which usually contains some Pb in it, to protect him/herself from the X-ray and/or gamma radiations used in taking images of the organs to be treated. It has been found that people who are exposed to daily X-ray radiation may have a lifetime occupational cancer risk. According to the US' National Cancer Institute, radiology technicians who worked before 1950 have an increased risk of developing cancer, especially blood cancer (leukemia), breast cancer, thyroid cancer, and skin cancer [135].

In brief, radiation is all around us – called background radiation – but this should not be a cause for fear. Different types of radiation behave differently and, as such, some forms or kinds of them are highly beneficial.

3.2. Heat (thermal energy) transfer

Heat transfer's experiments explore how thermal energy is transferred from one object to another. Transfer of heat (thermal energy) occurs when particles in a system have kinetic, potential energy transferred to other particles. Thermal energy transfer involves the transfer of internal energy, which is the total amount of kinetic energy of all the particles in a system. The temperature is proportional to the average kinetic energy of the atoms and molecules in a substance, and the average internal kinetic energy of the substance is higher when the temperature of the substance is higher.

Experiments show that heat transferred from or to a material depends on three factors. These are the change in temperature of the material, the mass of the material, and certain physical properties related to the phase of the material. One of these physical properties is the specific heat, denoted to as c. The specific heat of a substance is the amount of energy required to raise the temperature of 1 gm of the substance by 1 ^{o}C. Table 3 shows a few examples of some materials (solids, liquids, and gases) with their c values. Table 3 shows, for instance, that c for water (4,186 J/(kg·°C)) is almost five times greater than that (c) for glass (840 J/(kg·°C)). This means that it takes five times as much heat to raise the temperature of 1 kg of water as it does to raise the temperature of 1 kg of glass by the same number of temperature degrees.

Table 3. The values of specific heat (c in J/(kg·°C)) for a few materials of solids, liquids, and gases ([136])

Solids		Liquids		Gases (at 1 atm constant pressure)	
Material	Specific Heat J/(kg·°C)	Material	Specific Heat J/(kg·°C)	Material	Specific Heat J/(kg·°C)
Aluminum	900	Benzene	1,740	Air (Dry)	1,015
Asbestos	800	Ethanol	2,450	Ammonia	2,190
Concrete, Granite (average)	840	Glycerin	2,410	Carbon Dioxide	833
Copper	387	Mercury	139	Nitrogen	1,040
Glass	840	Water	4,186	Oxygen	913
Gold	129			Steam	2,020
Human Body (average)	3,500				
Ice (average)	2,090				
Iron (Steel)	452				
Lead	128				
Silver	235				
Wooden	1,700				

There are three ways through which heat (thermal energy) can travel through materials: Convection, conduction, and radiation. Convection is the transfer of heat through the movement of fluids, such as air or water. Conduction is the transfer of heat through direct contact between objects, which occurs when there is a temperature gradient or difference between two objects. Some examples of heat transfer through conduction include pouring hot water into a cup, where collisions between the high temperature molecules and atoms of the cup cause energy to transfer from the hot water to the colder cup. Another example is when an ice cube, for instance, is placed on a warmer surface and the collision between the molecules and atoms of the surface and the ice causes thermal energy to transfer from the warmer surface to the colder substance (ice in this case), causing it to melt. For example, Shiken [137] investigated the rate of conduction in different metals, and compared the rate of thermal energy transferred in four different types of metals (iron, brass, copper, and aluminum), with the goal of determining which metals have the highest and lowest rates of conduction. The results indicated that copper has the highest thermal conductivity, while iron has the lowest thermal conductivity, which is, by the way, a well-known fact.

Heat radiation is the transfer of heat through electromagnetic waves, such as infrared radiation. It is a form of heat transfer that occurs when electromagnetic radiation is emitted or absorbed. Electromagnetic radiation includes radio waves, microwaves, infrared, visible light, ultraviolet light, X-ray, and gamma ray, all of which have different wavelengths and different quantities of energy (shorter wavelengths have higher frequencies and more energies) (Figure 3; above). Another example of radiation is thermal radiation from the human's body. People are constantly emitting infrared radiation, which is not visible to the human's eye, but is felt as heat. Thermal radiation is the only method of heat transfer where no medium is required, meaning that heat does not need to be in direct contact with or transferred to any material. The space between the Sun and the Earth is largely empty with no possibility of heat transfer by convection or conduction. Instead, heat is transferred by radiation, and the Earth (its continents and oceans) is warmed as it absorbs the electromagnetic radiation emitted by the Sun. All objects absorb and emit electromagnetic radiation. The rate of heat transferred by radiation depends mainly on the color of the object. Accordingly, black color is the most effective absorber and radiator, while the white color is the least effective.

3.3. Industrial challenges facing the use of various materials

Nowadays, challenges in electronic and electric equipment's design include eco-environmental implications [138], heat countermeasures [139], nanomaterial, nanotechnology, and nanoscience applications [140–142], optimizing efficiency [143], downsizing [144], and electromagnetic compatibility (EMC) support [145,146], as well as introducing and applying artificial intelligence – AI – and machine learning – ML – [147–149].

Heat is one of the most important considerations as it affects the performance and reliability of parts of equipment, as well as their safety. Accordingly, thermal resistance and heat dissipation consider the importance of semiconductor's parts, such as integrated circuits and transistors, as being used in electronic and electric equipment. Therefore, it is necessary to design the equipment with possible highest safety standards, so that the absolute maximum temperature of each part that makes up the equipment is not exceeded.

Because problems caused by heat are potentially very life-threatening, as causing malfunction, smoking, igniting products, and/or fire, thermal design is critically and specifically important. High temperatures significantly reduce the life of electronic and electric equipment and, therefore, efficient thermal evacuation becomes a technical challenge for this type of applications, which in many cases, requires the installation of powerful cooling equipment. Hence, it is necessary to carry out reliable thermal design of manufactured equipment from the initial stage.

4. Materials and methodology

To conduct the intended experiment – DET, two kinds of tools were used. These are 68 materials divided into nine groups, and wooden rods fixed on them two capsules filled with the different crushed materials prepared. One capsule includes one material from each of the nine different groups, meaning that it includes nine different materials. The other capsule includes the material that should be detected or dowsed and, possibly, could be located and identified, as explained below.

4.1. Materials used (68) and divided into nine different groups

The applied (technical and practical) part of the research work presented in this paper took place in various locations in Jordan and Palestine over a period of two full years, started on 1 April 2021 and ended on 1 April 2023. The experimental research included field work, laboratory work, and computer analysis and modeling work. Furthermore, the work included writing and presenting the obtained results in the present paper for the purpose of publishing it internationally. Accordingly, it will be available for those who are interested in such experimental work, including research scientists, mineralogists, physicists, geophysicist, chemists, geochemists, geologists, dowsers, and psychologists. This is also with the intention of getting endorsement and support that may be provided by concerned universities, companies, and research institutes, nationally, regionally, and internationally to further continue the experiments and prove their applicability, regarding various areas of knowledge and interest. Perhaps the next step for such research is to apply digital tools, Google Maps, artificial intelligence, and machine learning to further understand and interpret DET in relation to hidden materials.

To achieve the purpose of this research, 68 samples were collected from various locations in both countries – Jordan and Palestine. For example, the metals, such as gold (Au), silver (Ag), and copper (Cu) were obtained from locations in Palestine; while zinc (Zn) was bought from stores selling such materials in Jordan; chromium (Cr) was taken from lithium (Li) batteries; while the lithium row material was granted from laboratories that belong to the Atomic Commission of Jordan. Meanwhile, the manganese (Mn) sample was obtained from the Natural Resources Authority (NRA) of Jordan, considering the fact that the second author had worked for NRA as a mining engineer for almost 35 years.

The available 68 samples were divided or classified into 9 groups (from G1 to G9) as follows (Table 4; Figure 5-Left and Right), based, generally, on their chemical and mineralogical, composition, as well as their lithological characterization:

G1: Includes 12 native metals (or semi-minerals), such as gold, silver, copper, zinc, etc.

G2: Includes 11 minerals and metal ores that contain in their composition considerable amounts of combined native metals, such as malachite (copper ore), hematite (iron ore), aluminum clay minerals and pottery materials that are rich in aluminum (Al) due to the presence of clays in their composition.

G3: Includes 25 different materials which are non-metalliferous rocks and minerals, such as carbonate rocks, quartz, zircon, etc. They do not have in their chemical composition associated metals of considerable amounts. These 25 different materials are also known by their transparency, meaning that they are able to transmit light when examined microscopically.

G4: Includes 8 non-metal native elements, such as native sulfur (S) and organic carbon (C), existing in charcoal, green plants, plastics, rubber, crude oil, oil shale, and natural gas.

G5: Includes 3 sulfide minerals that contain considerable amounts of combined native sulfur (S) in their chemical composition along with iron (Fe), lead (Pb), and mercury (Hg), namely pyrite (FeS_2), cinnabar (HgS), and galena (PbS).

G6: Includes 2 sulfate minerals that contain SO_4 in their chemical composition, namely gypsum ($CaSO_4.2H_2O$), and barite ($BaSO_4$).

G7: Includes 2 radioactive rocks composed of phosphate (PO_4^{3-}) that contain in their chemical composition secondary uranium (U) that emits gamma ray.

G8: Includes 1 material which is a magnetic mineral in the form of a natural magnet.

G9: Includes amorphous silicate rocks that have in their chemical composition amorphous silica (SiO_2) in the form of tridymite and cristobalite.

Table 4. The 68 different substances, including metals, minerals, rocks, ore deposits, and other materials that were collected from various locations in Jordan and Palestine, and divided into nine different groups, depending primarily on the chemical and mineralogical composition and lithological characterization of the collected materials

G1		G2		G3		G4	
Metal or Semi-mineral	Description	Ore Metals	Description	Rocks, Minerals, and Other Materials	Description	Nonmetal Native Elements	Description
1. Gold (Au)	Alloy	1. Marl	Aluminum metal ore	1. Chalk	Carbonate rock	1. Native Sulphur S	Non-metal native sulfur element
2. Lead (Pb)	Alloy	2. Clays	Aluminum metal ore	2. Dolomite	Carbonate rock	2. Green plants	Native Organic Carbon (C)
3. Silver (Ag)	Alloy	3. Pottery	Aluminum metal ore	3. Limestone	Carbonate rock	3. Charcoal	Native Organic Carbon (C)
4. Iron (Fe)	Alloy	4. Chrysocolla Cu mineral	Copper metal ore	4. Marble	Metamorphic rock	4. Oil shale	Native Organic Carbon (C)
5. Copper (Cu)	Alloy	5. Malachite Cu mineral	Copper metal ore	5. Mudstone	Mud rock	5. Plastics	Repeating Carbon units or chains (C)
6. Mercury (Hg)	Liquid	6. Pyrolusite Mn mineral	Manganese metal ore	6. Sandstone	Silicate rock	6. Rubber	Native Organic Carbon (C)
7. Zinc (Zn)	Powder	7. Magnetite Fe mineral	Iron metal ore	7. Soil	Red color alluvium	7. Crude oil	Native Organic Carbon (C)
8. Lithium (Li)	Alloy	8. Hematite Fe mineral	Iron metal ore	8. Hornblende gabbro	Igneous rock	8. Natural gas	Native Organic Carbon (C)
9. Chromium (Cr)	Alloy	9. Goethite Fe mineral	Iron metal ore	9. Granit	Igneous rock		
10. Manganese (Mn)	Alloy	10 Lithium ore $LiOH.H_2O$	Lithium metal ore	10. Rhyolite	Igneous rock		
11. Aluminum (Al)	Alloy	11. Lithium ore $BLiO_2$	Lithium metal ore	11. Basalt	Igneous rock		
12. Tin (Sn)	Sheet			12. Volcanic tuff	Igneous rock		
				13. Volcanic glass	Igneous rock		
				14. Schist	Metamorphic rock		
				15. Quartz	Silicates		
				16. Zircon	Igneous mineral		
				17. Plagioclase	Igneous mineral		
				18. Biotite	Igneous mineral		
				19. Orthoclase	Igneous mineral		
				20. Garnet	Metamorphic mineral		
				21. Halite NaCl	Salt		
				22. Bones	Calcium-made		
				23. Industrial glass			
				24. Marly limestone	Carbonate rock		
				25. Natural cotton	Cellulose		
G5		G6		G7		G8	
Sulfide Minerals		Sulfate Minerals		Radioactive Rocks		Magnetic Material	
1. Pyrite (FeS_2)	Sulfides family	1. Gypsum mineral $CaSO_2.2H_2O$	Sulfate family	1. Phosphate rock rich in uranium U	Emits gamma ray	1. Magnet of pure iron Fe	Generating magnetic field
2. Cinnabar (HgS)	Sulfides family	2. Barite mineral $BaSO_4$	Sulfate family	2. Chalk rich in uranium U	Emits gamma ray		
3. Galina (PbS)	Sulfides family						
G9							
Amorphous silica (tridymite and cristobalites)							
1. Chert	Amorphous silica						
2. Porcelanite	Amorphous silica						
3. Siliceous shells	Amorphous silica						
4. Tripoli	Amorphous silica						

4.2. Wooden rods

Wooden rods (bars or sticks) were used to practically implement the experiment. They were taken from an oak tree of a good quality, as wooden rods have proved to be a suitable material to be used as a detector of choice amongst other materials (i.e., copper, iron, glass, or otherwise) – not to mention they are isolators. They were prepared with the same design, having a length of 40 cm, a height of 16 cm, and a diameter of 1 cm (Figure 6; below).

It was found that the dimensions of the used rods are suitable to conduct the experiments, because the dimensions of these rods enable the investigator to easily handle the rods, to control and adjust them, and also to avoid the effects of wind movement in various directions and at different speeds that may affect the rods during practice.

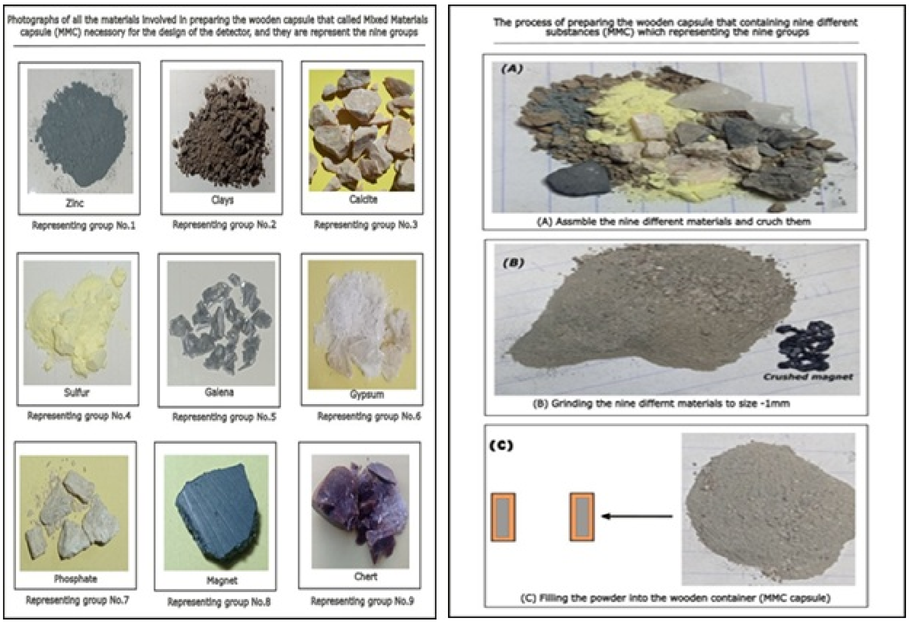

Figure 5. Left: Mechanical preparation of the nine different crushed materials that represent the mentioned 9 groups to conduct the experiments; Right: The nine different materials, representing the 9 different groups that represent the 68 substances investigated, were crushed, pulverized, grinded, mixed together, and filled in the Mixed Materials Capsule (MMC) shown in Part C of the Figure on the Right side

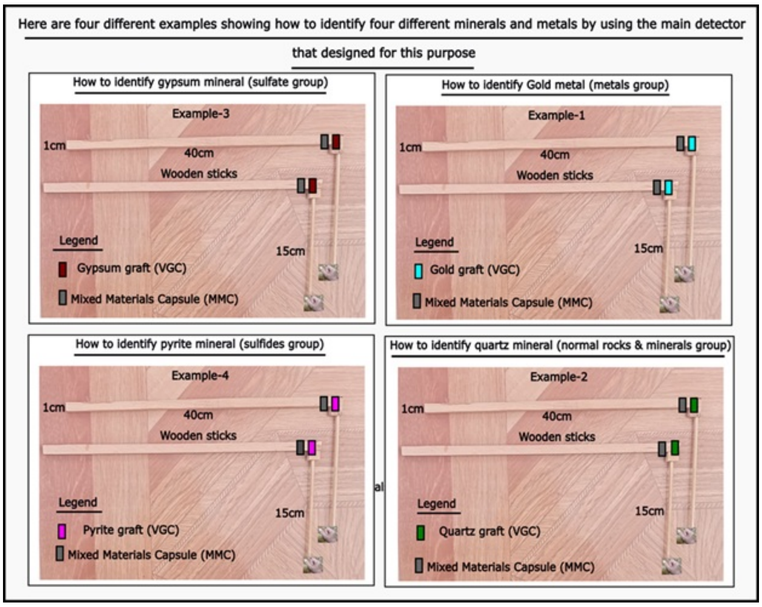

Figure 6. Four examples explaining the conducted experiment: The wooden rods supported (grafted) with the mixed materials capsule (MMC), along with the variable graft capsule (VGC) that contains, separately, one sample of each of the nine groups; for example gypsum ($CaSO_4.2H_2O$), gold (Au), pyrite (FeS_2), quartz (SO_2), etc. that were searched and targeted

4.3. Implementing the experiment

After preparing the 68 materials and dividing them into 9 different groups (as shown in Table 4; above), they were crushed, grinded, and put in two capsules (Figure 5; above). A capsule was filled with a mixture of nine selected samples, named "mixed materials capsule" (MMC), which was then fixed on the wooden rods (Figure 6). Another capsule, named "variable graft capsule (VGC)," was filled with a single changeable material that represents each of the 9 different groups, which was then mounted on the wooden rods (Figure 6).

For example, gold represents the metals or semi-minerals' group (G1); quartz represents the non-metalliferous' group (G3), pyrite represents the sulfides' group (G5), gypsum represents the sulfates' group (G7), and so forth.

5. Results and discussion

As explained above, this research paper has briefly analyzed and discussed the chemistry and physics of various minerals and metals found on the Earth's surface, and has also analyzed and discussed their physical behavior, in terms of energy radiation and conduction. Meanwhile, the third part of the study has described the materials used in the dowsing experimental technique – DET, as being the target of this research. The following parts of this research have attempted to explain the results obtained, and interpret their actions and interactions in relation to DET.

5.1. Materials' identification using wooden rods and two capsules

The current research experiments were conducted on 68 different materials collected from various regions in Jordan and Palestine, as mentioned earlier. They included minerals, metals, semi-metals, ferromagnetic minerals, rocks, radioactive materials, etc. (Table 4; above). Wooden rods (bars or sticks) were used to achieve the objectives of the experiments conducted on-site, as already demonstrated. The experiments revealed 9 different groups representing the 68 different materials examined. It is believed that the differences between these different groups of materials cover the differences between all the materials on the Earth's surface, as discussed earlier, under "*Background: Earth's Rocks and Earth's Crust*".

The focus of the current research was on the wooden rods fitted with a capsule containing a mixture of 9 pulverized samples (Table 4), while each sample represented one of the 9 groups that made up the 68 materials examined (Table 4). This capsule is named "mixed material capsule" (MMC). Another capsule was filled with a single material only that was selected out of the 9 different groups every time the experiment was conducted. This capsule is named "variable graft capsule" (VGC) (Figure 6; above).

The experiment was demonstrated in six different steps, which are:

1. Free rods without using any of the two capsules: This makes the rods take a horizontal position or line at 180 degrees, indicating that they are unable to identify any of the materials searched, because there is no material to search and be identified and inspected.
2. The two rods provided by the two different capsules (VGC and MMC): In this case, the rods can be called a detector designed to identify all the different materials to be searched for.
3. The rods are equipped with the variable graft capsule – VGC – which contains one selected material: In this case, the rods will search the same material and/or any other material belonging to the same group. For example, if the wooden rods are backed with a gold sample, the rods will search and recognize all the materials that belong to G1 (Table 4; above). If the rods are backed by a quartz sample, the rods will search and identify all the materials that belong to that group – G3 (Table 4; above). Also, if the rods are supported by a chert sample, for example, the rods will search and recognize all the materials that belong to that group – G9 (Table 4; above), and so on.
4. The rods are equipped with the mixed materials capsule – MMC – which contains one material from each of the nine groups: In this case, the rods will be in a position to take a straight line forward, meaning that there is no specific material to search for.
5. The rods are equipped with the two capsules (VGC and MMC) together, but one material is missing from MMC: In this case, the rods will begin search for the missing material in the investigated area, and if it is present, both rods go to identify this missing material wherever it locates.
6. The investigator (or dowser) stands directly above a target material, carrying in both hands the rods equipped with both capsules: In this case the two rods form a sharp angle back and lean on the shoulders of the investigator.

The results of the current research indicate the following:

1. The designed detector (a dipping device made of wooden rods and two capsules (MMC and VGC) attached to the rods containing crushed materials) that was developed for the purpose of this research is capable to identify targets located within an area of 200 m radius, whether the targets are exposed on the ground-surface or located under the ground-surface.

2. The detector has the ability to identify targets that are located above or below the level of the wooden rods handled by the investigator, which are equipped with one bait material and/or the various crushed materials inside the capsules installed on the rods, individually or both together.
3. In the event that there is one target in the investigated area, the wooden rods can easily identify it, as the two rods will be directed towards the target so that they point together towards it.
4. If there are many similar target materials in the investigated area, the detector will recognize only the one closest to it and will not recognize the rest.
5. Unless the detector is located at the same distance from two similar target materials, each of the two wooden rods of the dowsing device will point at both targets.
6. If the target is located at the same level of the detecting rods, the target can be identified easily and, in this case, the rods will take an acute angle towards the back direction, as they will be connected to the investigator's shoulders and will rest in the back.
7. The designed detector – DET – has the ability to recognize and follow moving target materials at slower speed.

5.2. Interpretations

As the DET experiments have been conducted, as explained above, the question is: what do the results of these DET experiments mean and how they can be interpreted? As well known, the wooden rods in DET do not contain energy that exists in the form of ray radiation or heat and electricity conduction, which is due to the fact that they are isolators because they are made of wood. This means that the target to be searched, identified, recognized, and probably located is the material that may generate energy, in terms of radiation, heat or electricity conduction. The DET used in this research study can be naturally explained as the wooden rods may extend or enlarge the investigator's personal magnetic field. In addition, the rods are affected by the static electricity generated by the examiner's body. This may generate an electromagnetic field (EMF) that surrounds the experiment. In turn, such EMF responds to, and interacts with, the vibrational frequencies of the Earth, which makes the rods move towards the target material. According to Fercik [150], the dowsing rods are powered by *"human neuro-electrical signals,"* whereas walking while dowsing seems to build a static charge strong enough to move the rods while searching a target material.

However, despite this interpretation of DET to identify different materials, based on pure physical/natural aspects and understanding as discussed above, some researcher believe that DET can be interpreted with respect to the science of phycology. This means that the tactile movement of the rods is likely due to ideomotor influence, where subconscious small muscle movements are influenced by the investigator's expectations or beliefs. In controlled scientific studies, dowsing has not been shown to be more effective than a random chance. Therefore, some scientists consider dowsing to be pseudoscience.

Nevertheless, the results achieved in this study indicate that DET seems to be fitting between natural science, psychology science, and pseudoscience, as it has always been a mystery. Nobody can explain how it works but many believe it exists as demonstrated in the current comprehensively conducted research. Accordingly, DET has been a subject of discussion and controversy for thousands of years, as presented in this research paper, and probably will continue to be so. There is a history of mysticism, magic, and supernatural beliefs associated with dowsing experimental technique – DET, dating back over 8,000 years.

The question is: can new digital techniques and cyber-psychology, such as artificial intelligence – AI – and machine learning – ML – help explain the dowsing experimental technique – DET? Software-based deep learning techniques (for instance, AI and ML) have achieved tremendous success, but the real world is made up of materials [151]. Researchers are turning to AI to help develop new materials to provide better electronics and transportation, and to provide the energy needed to power them. Having witnessed this firsthand, Dr. Alexandre Boucher, Vice President of Seequent Labs and one of the world's leading geo-statisticians, has identified the massive amounts and unstructured spread of data as one of the biggest obstacles to deploying AI underground [152]. If we look at any of the AI success stories, they have the ability to structure large language ML models, using massive amounts of data. Regarding the underground, as dealing with unknown information because the data is often nonexistent or unstructured; we rely on techniques like mapping and drilling to find it. And even when we do have data, it is often isolated—in project files, on an individual's hard drive, saved in different file formats, and structured according to a wide variety of data standards—which means it cannot be easily integrated. Advanced utility mapping solutions, powered by satellite imagery, ML and AI technologies can help create an accurate representation of subsurface infrastructures and underground materials, remotely [153–155].

5.3. Factors and conditions affecting mineralization and dowsing technique

Regarding the dowsing (or dipping) technique – DET – applied in this research study, using 68 samples of minerals, metals, and other materials collected from different sites in Jordan and Palestine, the various factors and conditions mentioned above should be taken into account, regarding the mineralization and metallization processes, as well as target minerals, metals, and other materials investigated. Accordingly, as discussed above, some factors are more important and effective than others in locating these materials, using DET.

Five factors are re-emphasized here, which are: 1) The depth of burial of the target materials searched for; 2) Their availability in various quantities; 3) Geogenic and anthropogenic patterns and environmental impacts; 4) Sedimentary and structural elements; and 5) Climatic conditions. These five factors and conditions appear to be more important for DET than some others discussed above. Therefore, the presence of target materials at certain depths associated with various quantities of the desired target(s), taking into account geogenic and anthropogenic patterns and environmental impacts, makes DET practical and successful, particularly in contribution to achieving the UNSDGs [156]. This is because using DET to search for and locate target materials helps combat the effects of climate change by reducing greenhouse gas emissions, improving forest resilience, managing efficiently natural resources, and protecting the environment, as well as reducing poverty levels and increasing employment rates in communities [157,158].

Regarding the effect of depth while using DET, it was found that DET is still able to detect materials at different depths examined in the experiment, including 3m, 5m, and 6m. These experiments were conducted on an empty borehole. The results showed that the target materials were successfully identified using DET. Regarding the quantities of searched materials, it does not matter if they exist in small, tiny quantities, or in large amounts and, therefore, DET is able to detect the locations of the target materials, regardless their estimated amounts. Moreover, erosion, weathering, and structural elements such as faults, folds, shear zones, etc. appear to have no effect on DET, as hidden materials are revealed regardless of these sedimentary and structural elements. In addition, climatic conditions, such as humidity, precipitation, and evaporation, have no effect on DET, as DET is still capable of revealing hidden materials under different climatic conditions.

6. Conclusions and recommendations

Minerals and metals are essential for almost all aspects of life. Their fundamental uses have greatly empowered many sectors, such as agriculture, healthcare, communications, water and energy supply, transportation, space technology, and urbanization (such as construction of infrastructures and cities). Nowadays minerals and metals have become more important and necessary, as they have helped in providing pathways to a greener, safer, and more sustainable future, in contribution to the United Nations' Sustainable Development Goals – UNSDGs.

The mining industry is pivotal to the global economy. Revenues of the world's 40 largest mining companies worldwide, which represent the vast majority of the entire mining sector, reached a record high of USD 943 billion in 2022, declining to an estimated USD 792 billion in 2024 [159]. Some observers expect that the minerals' market will grow to more than USD 2.4 trillion in 2025 [160]. However, environmentally friendly tools should be considered in the mining industry, especially since this industry causes significant environmental pollution to the air, soil, and water resources, and severely damages public health and vegetation. Moreover, poor countries that possess those natural resources of the minerals and metals deserve a more just and equitable distribution of the generated revenues, not to mention the fact that the mining industry is managed, controlled, and operated by large Western corporations [161–165].

The evidence of the existence of 9 different groups in this experimental field work, which have their chemical, physical, mineralogical, metallic, heat conduction, and radioactive properties, is an important scientific achievement, as being a good step towards understanding the chemical and physical behaviors of the studied materials. Indeed, this achievement would be a great addition to the fields of *"Minerals' Chemistry and Physics, and Materials' Science and Engineering,"* as well as other related fields of knowledge and study, such as psychology and cyber-psychology. This is particularly important because the nine groups of the materials, researched, investigated, analyzed, discussed, and presented in this paper, cover most of the upper part of the Earth's crust.

The innovation of the phenomenon of the presence of rays or different kinds of energy of these nine groups can be a stimulus for the design of new technical devices that are compatible with what has been achieved and presented in this research paper for the detection of minerals, metals, rocks, and other materials that may include water and hydrocarbons.

The detector developed for the purpose of this research is characterized by its ability to detect various types of metals, minerals, rocks, and ore deposits, whether above or below the ground's surface, especially near-surface targets located within an area of a horizontal distance of up to 200-m radius. The experiments – DET – were conducted on the ground's surface and under shallow soils, as well as at three different depths, using an old empty borehole in the area of investigation.

This study presents the completion of the design and production of a practical detector for the detection of metals, minerals, rocks, and other types of materials. This detector (or dowser) can be equipped with two capsules; one of them has variable bait, depending on the targets to be searched for, and the other capsule contains the rest of the materials representing the nine groups investigated. This detector is easy to carry, handle, and use in the field without being affected by weather conditions or other influences discussed in this paper. The technique – DET – is also cheap, inexpensive, and environmentally friendly.

This research has proven that using a detector made of wooden rods is much better than using rods made of copper, iron, or other metals, because wooden rods do not conduct or affected by any kinds of energy that may be generated by the materials under investigation or by the investigator.

In conclusion, physically speaking, some scientists believe that the electromagnetic field is behind the dowsing experimental technique – DET – applied in the present research, while some other scientists believe that piezoelectric effects are behind it, and a third group believes that DET is affected by heat conducted through vacuum and the various materials examined. The components of atoms within the examined metals, minerals, rocks, and other materials emit ionizing radiation of various kinds. In particular, the DET mechanism(s) is/are represented in the form of normal radiation, thermal conductivity, and/or piezoelectric effects of each of the investigated materials. Meanwhile, other scientists believe that DET is just a psychological phenomenon and, if so, it needs further research studies and investigations. In this case, digital tools, such as artificial intelligence, machine learning, and cyber-psychology, should be introduced and investigated.

Since the research presented in this paper focuses on DET, remarkably a comprehensive literature review was done, which covers the literature published over decades in relation to DET and its various practices, expectations, analyses, and interpretations.

As a final note, the applied dousing experimental technique – DET – and its results obtained and presented in this comprehensive research paper will be a good addition to the sciences and practices of metallurgy and mineralogy, as well as many other related fields of knowledge and applications; namely psychology of consciousness.

Nomenclatures (Abbreviations and Units Used)

Abbreviations

AI Artificial Intelligence (AI)
c Specific Heat (depending on the material and its phase)
DDRS Digital Dowsing Rod System
DNA Deoxyribonucleic Acid
DET Dowsing Experimental Technique
EMC Electromagnetic Compatibility
EMF Electromagnetic Field
FM Frequency Modulation
GLA Greater London Authority, London, UK
GTs Geophysical Techniques
IARC International Agency for Research on Cancer
ICTs Information and Communication Technologies

IR Ionizing Radiation
ItP Introduction to Psychology
MMC Mixed Materials Capsule
NATO North Atlantic Treaty Organization
NIR Non-Ionizing Radiation
m Mass of Material
ML Machine Learning
P Waves Seismic Compressional Waves
PPM Proton Precession Magnetometer
Q Heat Transfer
RFDs Radiofrequency Diseases
SCLLB Semiconductor Laser Light Box
SI International System of Units
SIAL Silicate and Aluminum's Continental Crust
SIMA Silicate and Magnesium's Oceanic Crust
S Waves Seismic Shear Waves
TVs Televisions
UK United Kingdom
UNSDGs United Nations' Sustainable Development Goals
uPVC Unplasticized Polyvinyl Chloride
VES Vertical Electrical Soundings
VGC Variable Graft Capsule
Wi-Fi Wireless Fidelity

Units

ºC Degrees Celsius
cm centimeter
gm/cm^3 gram per cubic centimeter
J/(kg·°C) Joule per kilogram per degrees Celsius
J/(kg·K) Joule per kilogram per degrees Kelvin
K Degrees Kelvin
kg kilogram
km kilometer
km^2 kilometer square
m meter
MPa Mega Pascal
m/s meter per second
ppm parts per million

Funding Information: The research presented in this paper did not receive any funding from any individuals or organizations.

Conflicts of Interest: There is no potential of interest of any kind (financial or otherwise).

Data Availability: All data and materials needed and used to serve the purpose of this research paper are provided within.

Author Contributions: The first author – Prof. Dr. Hilmi S. Salem (Palestine) provided the analyses of the data collected and also wrote entirely the text of the research presented in the paper to be considered for publication. The second author – Eng. Ibrahim Rabba (Jordan and Palestine) conducted the experimental (practical) part of the research, and also prepared the figures (No. 5 and 6) that are directly related to the experimental field work.

Acknowledgments: The authors are grateful to friends and colleagues at laboratories of the Atomic Commission of Jordan, and the Natural Resources Authority (NRA) of Jordan for their kind assistance, cooperation, and communications during the experimental stage of the work needed for this research. The authors also express their sincere thanks to friends and colleagues who critically reviewed the paper.

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