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Human Archaeologists Still Required

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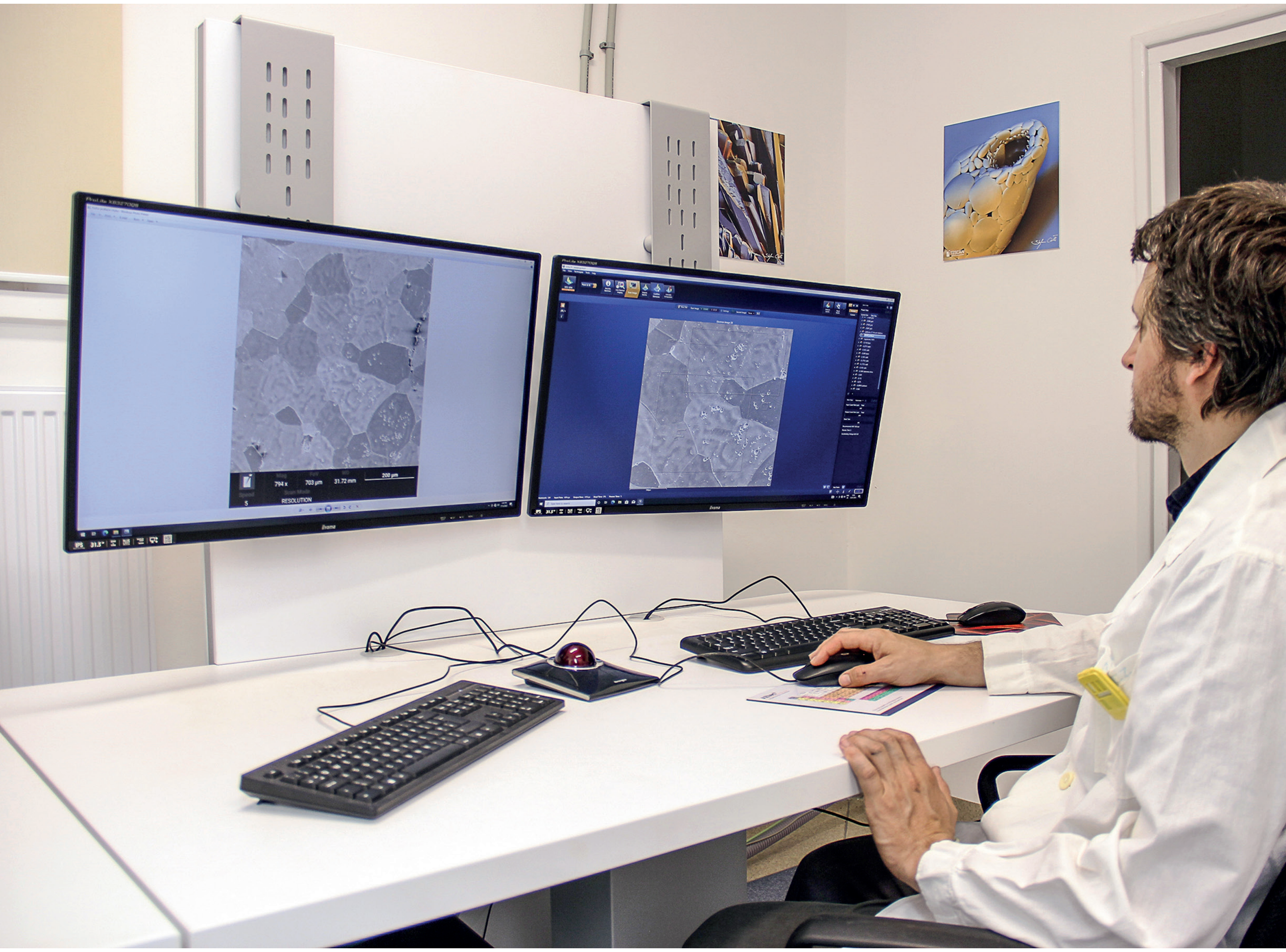
How technology is changing our view of the past – and how archaeology itself is evolving in response – is the subject of our interview with Mateusz Bogucki and Robert Ryndziewicz from the Laboratory of Bio- and Archaeometry at the Institute of Archaeology and Ethnology, Polish Academy of Sciences.

Do archaeologists sense that artificial intelligence poses a threat to their profession?
ROBERT RYNDZIEWICZ: On that point, I'm actually optimistic. I believe AI can greatly support our research work. I appreciate what it offers without over-hyping its role, and I follow with great interest the growing range of ways it's being used in archaeology. At this stage in the development of these technologies, I don't see them as a threat to the profession. Neural networks are powerful tools that allow us to process data on a previously unimaginable scale. Nevertheless, the key focus still lies in the minds of the people interpreting the past.
MATEUSZ BOGUCKI: Archaeology – arguably the most interdisciplinary of the humanities – has always been eager to embrace modern technologies. Meaning, of course, ones that were modern for their time.

It always has – but never on this scale, surely?
R.R.: To answer that, it's important to understand how archaeology has developed as a scientific discipline. One of the key turning points came in the post-WWII years, particularly the 1960s – a time of major paradigm shifts in archaeology. The discipline gradually moved away from simply collecting and describing artefacts and began considering broader aspects of how past communities functioned. This new approach became known as *processual archaeology*. One of its hallmarks was *epistemological optimism* – the belief that as our research methods became more precise, our understanding of the past would also improve. In fact, archaeology had been embracing innovative methods even earlier – and it continues to do so today. What's changed is that now there are far more methods and tools available.
M.B.: A good example is the research conducted at Biskupin, the famous Iron Age fortified settlement discovered in 1933. Back then, they used a tethered balloon equipped with a camera. This produced a collection of several thousand high-quality photographs documenting the excavations. Today, we use drones for the same purpose – the method remains the same, but the tools have changed. Not only are they more efficient, but they also allow us to see more and in greater detail.

How much has technology changed our understanding of the distant past?
M.B.: We only need to look at how large sites, such as the Piast stronghold at Ostrów Lednicki, are being studied. These large settlement complexes served multiple functions – and what's more, they were constantly evolving. Thanks to advanced equipment like ground-penetrating radar, we can now pinpoint the locations of residential areas, marketplaces, cemeteries, poor dwellings, fire pits, and workshops. Technology makes it possible to identify this original landscape at relatively low cost – and without destroying it. Lab research also often changes our interpretation of past phenomena. For example, studies of raw materials and production techniques have shown that objects we recover aren't always from the places that would be suggested by stylistic analysis of their shape or decoration. Microscopic and chemical analysis of



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ceramics, glass, and metals can reveal information that's invisible to the naked eye – about cultural connections, trade routes, and the transfer of ideas. To use a modern analogy: Levi's 501 jeans have looked the same for 150 years, but by studying the fibers, thread, and the metal in the buttons, you could determine whether a given pair was made in the United States, in the factory that used to operate in Poland, or perhaps in Thailand. In prehistoric contexts, that kind of information is invaluable: knowing whether an object was made locally or transported hundreds or even thousands of kilometers radically changes how we imagine the workings of early societies.

What specific technologies are we talking about in the case of archaeology?

M.B.: These days, there are many such technologies, and they almost always arise from collaboration between archaeologists and specialists in other disciplines. There's an entire branch of archaeology known as *archaeological science*, which combines the humanities with tools from the physical sciences. Today, advanced technologies are used at every stage of research – from the initial survey of an archaeological site, through excavation, to post-excavation analysis. One could say that a great deal of archaeological research today actually takes place in advanced laboratories, where we can carry out precise dating of samples, determine elemental and isotopic composition, and analyze DNA preserved in bones. The technologies we use were rarely developed specifically for archaeology – we more often adapt solutions from other fields to our needs. One of the first places in Poland to begin studying the past in this way was the laboratory at our Institute, which dates back to the 1950s. Then and now, its goal has been to give archaeologists access to the possibilities offered by modern analytical equipment. We specialize in the study of

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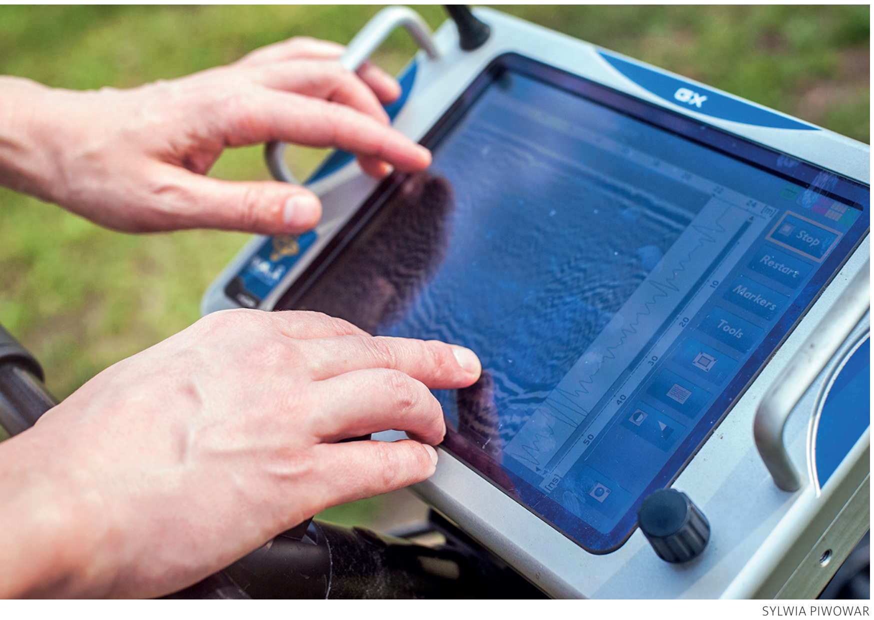
metal objects, ceramics, and plant remains, as well as the use of non-invasive geophysical and remote sensing methods in field research.

R.R.: Geophysical methods derive directly from the Earth sciences. They were developed to study the geological structure of the Earth's crust, search for mineral deposits, or investigate glaciers and the stability of rock masses. Once their scale – meaning the resolution and depth range – was adapted, they found broad application in the detection of underground archaeological remains. Frankly, it's hard to call them "modern," as archaeology has been using them for decades.

Where did it all start?

R.R.: The first geophysical survey of an archaeological site in Poland was carried out in 1960 by the Institute of the History of Material Culture (the predecessor of today's Institute of Archaeology and Ethnology, Polish Academy of Sciences) – when the electrical resistivity method was used to investigate the early medieval stronghold at Kalisz-Zawodzie. A year later, researchers from Kraków used magnetic methods at the ancient metallurgical center in Nowa Słupia. Initially, such work was done in collaboration with professional geophysicists, but advances in technology have enabled archaeologists to apply these methods independently. Today, archaeological geophysics is one of the most effective and cost-efficient ways to discover, document, and analyze buried structures, sites, and landscapes that are invisible on the surface. *Ground-Penetrating Radar* (GPR), in particular, is becoming increasingly widespread – and I believe it still holds extensive potential. Since 2017, our Lab has participated in dozens of projects using GPR – not just in Poland, but also in Sudan, Spain, Greece, and Italy. In many cases, our surveys yielded breakthrough data.



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What can GPR images tell us about our ancestors?

R.R.: To answer that properly, we first need to understand how geophysical methods work. Ground-Penetrating Radar allows us to observe how electromagnetic waves propagate through the ground. This helps identify subsurface stratigraphy and any discontinuities in it. The data we obtain is indirect – we're only observing certain measurable soil parameters. It's a bit like trying to describe the taste of a dish based on its color, density, or temperature. A true master chef might be able to tell what something tastes like without ever having sampled it. Archaeological geophysics is somewhat similar: we gather digital data without disturbing the soil and then have to interpret it to understand what's beneath the surface. Proper interpretation requires a deep understanding of the method, but also consideration of many other factors. We draw on aerial photography, satellite imagery, prior excavation or drilling data, and geological maps. By comparing and combining all of these, we can gain a more comprehensive understanding than excavations alone could provide.

Where have you used ground-penetrating radar?

R.R.: For example, to study the site of a late medieval castle in Żelechów, Mazovia. We also identified remains of the medieval town hidden beneath the modern urban fabric of Sandomierz, and we located what is likely the site of a mosque in Madīnat Ilbīra – one of the major cities of the Umayyad-ruled Caliphate of Córdoba. In collaboration with the Polish Centre of Mediterranean Archaeology at the University of Warsaw, we also investigated two of the three capitals of the medieval Nubian kingdoms in present-day Sudan: Old Dongola, the capital of Makuria, and Soba, the capital of Alwa.

You mentioned drones earlier.

M.B.: That's a relatively recent innovation, but one that has had a huge impact on archaeology. Drones are equipped with positioning systems, so the data they collect is precisely geolocated. That makes it much easier for us to produce detailed maps and plans of the areas we study – not to mention the cost savings compared to organizing traditional expeditions. The widespread adoption of LiDAR scanning – laser scanning carried out from an aircraft – touched off another breakthrough in archaeology. The laser beam emitted by the device reaches the ground, bounces back, and returns, allowing us to obtain detailed data about the terrain's topography. As a result, any archaeological features with even a faint surviving topographic signature – like hillforts, burial mounds, tombs, ramparts, or ditch systems – suddenly became much easier to detect. Even without leaving the office, we can now use publicly available data and AI algorithms to identify thousands of new sites in just a couple of weeks. LiDAR has also opened up a new frontier: forested areas, which have traditionally been hard to access, are now within our reach for detailed study.

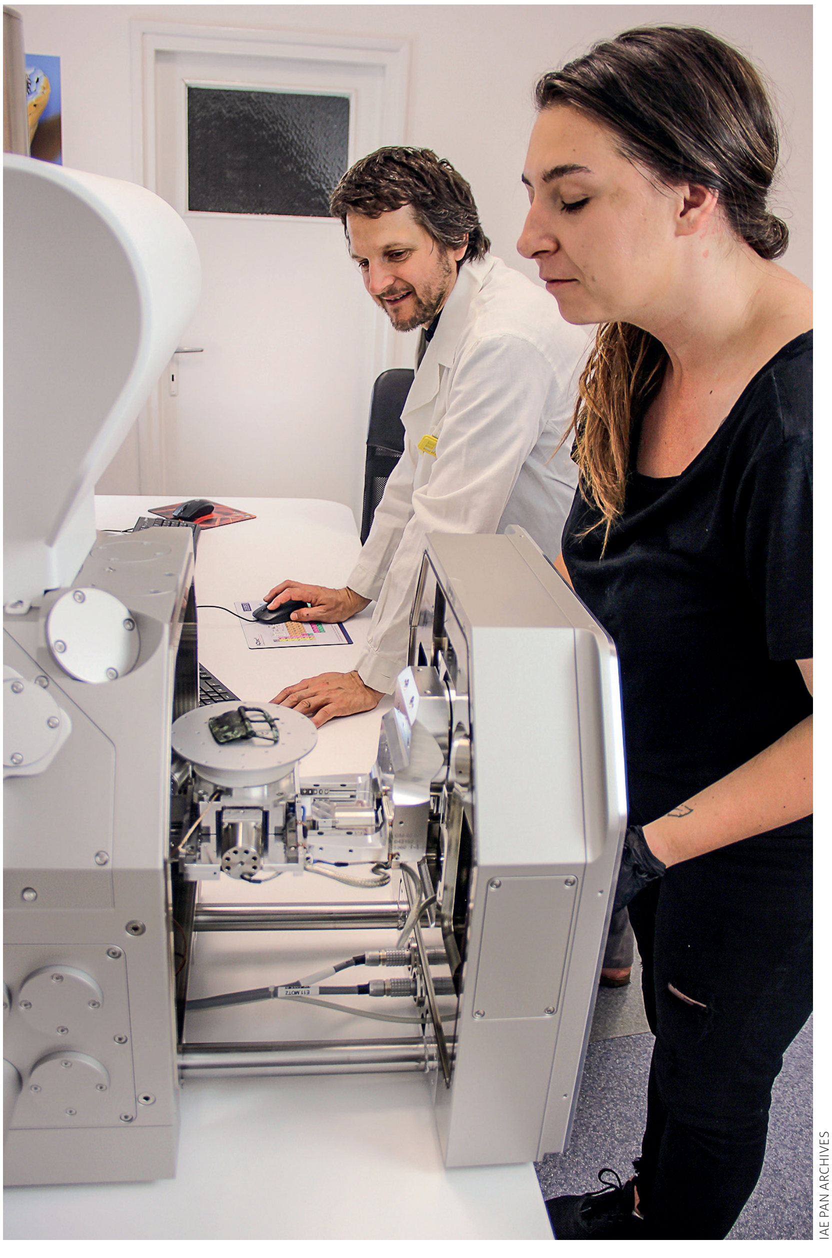
The common feature of all the tools we've discussed is that they're non-invasive. What practical significance does that have for archaeology?

R.R.: The European Convention on the Protection of the Archaeological Heritage, known as the Malta Convention, which Poland ratified in 1995, emphasizes that archaeological heritage is essential to understanding the human past and should therefore be protected and preserved *in situ*. Archaeological heritage is a non-renewable resource, and it's constantly at risk from economic development, landscape transformation, erosion, climate change, and looting. Over the past few decades, we've already lost a great deal, and we should be protecting what remains for future generations.

Non-invasive methods allow us to conduct research without disturbing the archaeological material itself. When excavation is either unnecessary or infeasible, these methods provide the optimal solution. The site mentioned earlier – Soba – lies on the outskirts of Khartoum, a large modern African metropolis that is gradually encroaching on the area of the medieval city. As a result, only a small part of the site – about 50 hectares, or one-sixth of the estimated total area – is still accessible. The rest is already built over or otherwise repurposed. We carried out geophysical surveys over the entire available area, obtaining a wealth of information about the layout of the city. Excavations were conducted only on carefully selected, limited areas to make the research process as efficient as possible. Based on non-invasive data, we were able to identify not just neighborhoods but individual buildings, roads, and other elements of the medieval urban fabric. By combining this information with other sources, we were able to answer many questions about the processes of urbanization in medieval sub-Saharan Africa. Just imagine how long it would take to investigate an area of that size using only excavation.

Does every advanced technology work equally well regardless of the site?

M.B.: By no means. The key is to choose the right methods – those that match the research questions we're asking and the specific conditions of the site. Dating methods are a good example. A turning point – especially for research on the early Middle Ages in Europe – was the development of dendrochronology. In the Paleolithic or Neolithic, where organic remains are rare, radiocarbon dating works well. But analyzing the annual growth rings in timber is particularly useful for more recent times – it has enabled us to better understand (though not fully reconstruct) the processes involved in the development of the Piast state. Timber logs were used for ramparts and houses. By studying this wood, we can determine its source. Prof. Tomasz Ważny conducted a series of analyses on samples from early medieval Wolin. It turned out that in the town's early phase, people used high-quality local timber – large, sturdy trunks that ensured the solidity of the buildings. But over time, they began importing lower-quality wood from farther



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Much of the archaeological research done today takes place in advanced labs, where samples can be precisely dated, elemental and isotopic compositions can be determined, and the DNA preserved in bones can be analyzed

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away, such as Mecklenburg. They started building with whatever they could find – salvaged wood, bits of boats. It's only through specialized research using modern methods that we're able to uncover that kind of context.

What more can these new tools reveal?

M.B.: Isotope analysis of metals is providing a wealth of new data. For example, we're investigating where the silver used to mint coins under the Polish rulers Bolesław the Bold, Władysław Herman, and Bolesław the Wrymouth came from. It turns out that, in addition to recycled silver, they also used local deposits from the Olkusz and Dąbrowa Górnicza regions. Another technique involves measuring strontium isotope levels in human dentine. At the early Piast-era cemetery in Bodzia near Włocławek, it turned out that some individuals had very different levels of this element compared to the local population. This suggests that, alongside locals, newcomers from Pomerania, Denmark, or the Kiev region were also buried there. Similarly, four warriors buried in the cemetery at Ciepłe were most likely born in Denmark.

We've talked about how technology is changing our view of the past – but is it also changing archaeology itself?

M.B.: We've discussed geophysical methods rooted in geoscience. Dendrochronology, on the other hand, stems from the natural sciences, though it found its most powerful applications in archaeology. Let me also mention what is still the most "human" stage of the work – the excavation. Sure, we still use trowels, brushes, and spades... but even here, things are changing. A colleague of ours working in Turkey is planning an excavation involving AI-guided robots. At this stage, documentation is incredibly important – and now photogrammetry and high-precision geodetic measurements are the norm. In the past, we used to use pencils and graph paper; now, photogrammetry gives us hundreds or even thousands of dimensionally accurate photographs of a single trench. On top of that, we can laser-scan the entire surface. That illustrates the difference.

R.R.: It's also important to remember that every excavation is destructive and one-time-only. If we miss something, that information is lost forever. That's why precise documentation is so vital. But today's challenges go far beyond that. Climate change is increasingly impacting archaeological heritage. Recently, in collaboration with Adam Mickiewicz University in Poznań and the National Heritage Board of Poland, I conducted a ground-penetrating radar survey at the site of a defensive settlement from the Bronze-to-Iron Age transition in Smuszewo. The primary goal wasn't to make new discoveries, but to evaluate how climate change is affecting this invaluable and extremely fragile site, which is preserved underground in the form of several-thousand-year-old wooden structures. The use of technology and archaeology's interaction with other scientific disciplines is not just beneficial – it's essential if we want to better understand how past societies functioned. Combining knowledge across fields and utilizing the tools developed by those disciplines can lead to entirely new discoveries. Molecular biology, for instance, gives us tools to analyze genetic material, helping us understand past human interactions. Geology enables us to trace records of past climate changes that likely influenced human behavior. And archaeology can, in turn, broaden the perspective of those other disciplines. Humans have always interacted with and altered their environment, so paleoenvironmental studies and archaeology go hand in hand. It's a very fruitful space for interdisciplinary collaboration.

Does that mean today's archaeologists need additional skills and competencies?

R.R.: Computers have revolutionized our methods from a technical standpoint, and there's no question that the list of necessary archaeological skills has expanded significantly in that direction. Of course, you can't learn everything – but keeping up with new technologies is now a basic requirement for researchers. One consequence of this shift, which is discussed less often, is the massive growth in digital data, which we then have to effectively manage in some way.

M.B.: GIS systems and large databases are a great help – they allow us to organize the material we've collected, sort and categorize it more effectively, and work with it more efficiently. We no longer have to sift through stacks of maps and paper sheets – it's all on the computer now. But you still have to learn how to navigate these systems.

What would archaeology look like today without modern technology?

R.R.: The answer is already implied in the question. New technologies are tempting to use – but it's not just about applying ever-more advanced tools to seek answers to old questions. One of the most beautiful things about science is that we can reframe old problems, look at them from a new perspective, and pose new questions. Technology can help us do that.

M.B.: If we imagine our current knowledge of the past but remove everything that came out of interdisciplinary research, we'd be left with site maps, hand-drawn illustrations of graves and hillforts, and typologies of pottery, weapons, and ornaments. In other words, we'd be back to the level of archaeology from the late nineteenth century. Still, we should remember that advanced tools and technologies aren't magic wands that give us all the answers – they're incredibly helpful. However, ultimately, it's still up to the human mind to decide what the findings mean and how to interpret them. So even with all the algorithms and artificial intelligence, the spirit of archaeology will endure.

INTERVIEW BY **MARIUSZ KARWOWSKI**

Ground-penetrating radar (GPR) tracks how electromagnetic waves propagate through the ground

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