ISAP NEWS

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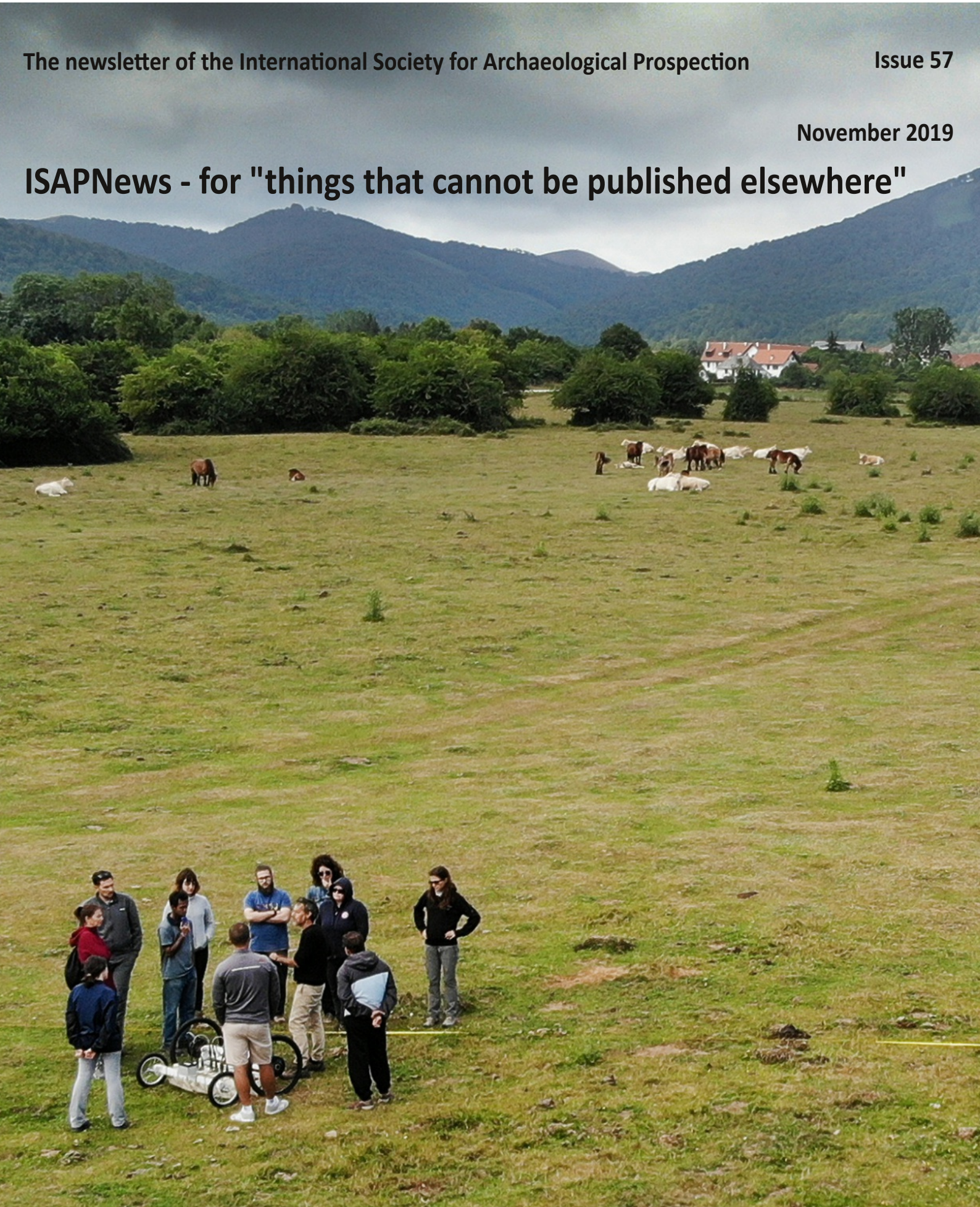
ISAPNews - for "things that cannot be published elsewhere"



Editorial

Dear Members,

ISAPNews - for "***things that cannot be published elsewhere***". That's the rather broad tagline that the Chair recently attributed to the newsletter. And the editorial team thought this is great! Exactly the description of what we expect you, the members, to submit for publication. Not journal articles, not Twitter posts, but something in between. Interesting images, work in progress, opinion pieces or simply interesting data (good or bad). And this issue certainly has not disappointed, with three very different pieces that we have reworked into a bumper edition.

You will probably all be eager to see the review of ICAP2019 in Sligo - so here it is. Those who were able to attend may find this a nice reminder, those who were not able to join in will feel double-keen to attend in two years time in Lion. We also have a very interesting scientific contribution that was part-financed by the ISAP Fund, and some impressions of the very successful training school run as part of the SAGA COST Action.

Armin Schmidt & Kayt Armstrong

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The Cover Photograph shows the GPR survey that was part of the first SAGA Training School (see page 19).

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Impressions from ICAP2019, Sligo, Ireland

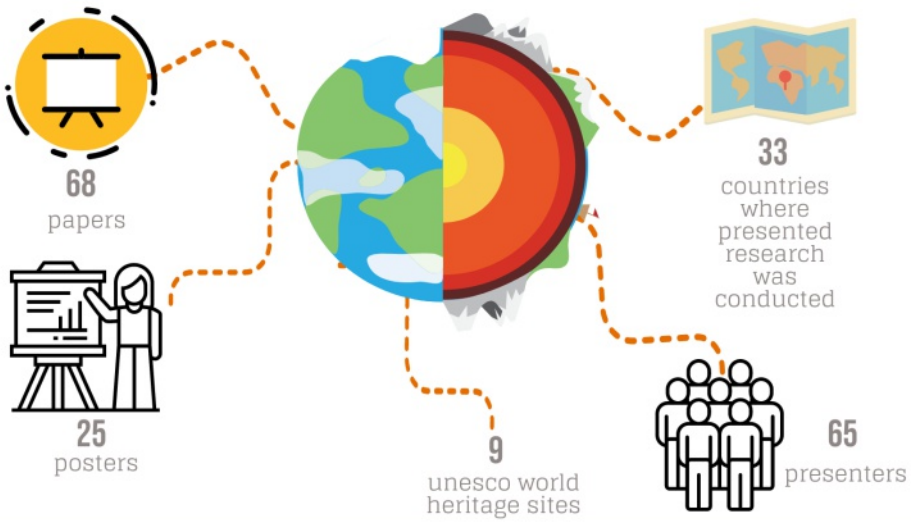
with contributions from ISAP Members **editor@archprospection.org**

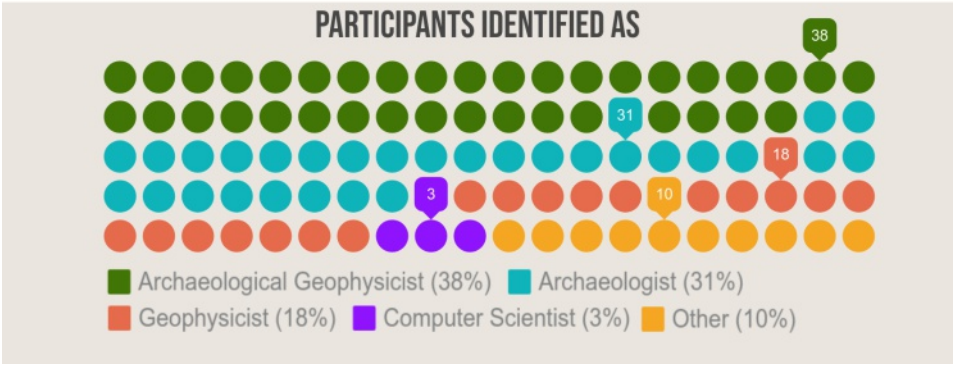
James Bonsall, Conference Organiser

The International Conference on Archaeological Prospection came to Ireland in August 2019, when the 13th ICAP took place at the Institute of Technology Sligo (IT Sligo), in the west of Ireland. Attracting 132 delegates from around the world, the conference featured a wide geographical spread of contributions and of individual presenters, reflecting the varied global approaches to archaeological geophysics and remote sensing. The conference was sponsored by Fáilte Ireland and the Institute of Archaeologists of Ireland and included exhibitions by Bartington Instruments, R. M. Frobisher, Allied Associates, DW Consulting, Mala GeoScience and a workshop on "Mounting Geophysical Instruments on UAVs: New Developments and Challenges" by Matt Guy from Geomatrix Earth Science.

Our four keynote speakers were Michael MacDonagh, Chief Archaeologist at the National Monuments Service, Rónán Swan, Head of Archaeology and Heritage at Transport Infrastructure Ireland, Virginia Teehan, CEO of the Heritage Council and Anthony Corns, Technology Manager at the Centre for Irish Archaeological Research, The Discovery Programme Company Ltd., who spoke about the varying ways in which archaeological prospection was used in Ireland, in terms of legislation, private sector and infrastructure, community and public heritage, and academic research, respectively.

The social programme featured a wine reception at The Model Arts Centre with the opportunity to visit The Niland Gallery which celebrates works by artists such as Jack Butler Yeats, Paul Henry, Norah McGuinness, Sean McSweeney, Dorothy Cross, Mainie Jellett, Mary Swanzy and many more. Our gala dinner at the Clayton Hotel featured traditional Irish entertainment with harp and cello performers Lar Easa Duo and the Bróga Bríomhar Dance School, joined by a number of sure-footed delegates for a final energetic 'brush dance'. ICAP delegates were also asked to state how they identified themselves within the archaeological prospection community and the very interesting results are summarised in the infographic.





On the fifth and final day, delegates attended field trips to Sligo's most impressive archaeological sites, including a hike up a mountain! The excursion began with a guided tour of Carrowmore, the largest cemetery of megalithic tombs in Ireland and among the country's oldest, with monuments up to 5800 years old. After an outdoor picnic, delegates hiked up Knocknarea Mountain for an additional guided tour on the Queen Maeve Trail, to visit Queen Maeve's Tomb, a large Cairn surrounded by Passage Tombs, thought to date to the Neolithic. Before saying their final farewells, we took a trip to Abbeyquarter Passage Tomb, the only megalithic cemetery located on a roundabout!

The conference abstracts were published as 'New Global Perspectives on Archaeological Prospection' by Archaeopress and are available in hard copy or as a digital Open Access volume. (http://www.archaeopress.com/ArchaeopressShop/Public/displayProductDetail.asp?id={9ED30272-7D87-40E6-8B56-333B1F5CE2D9})

Natalie Pickartz, Presenter

This was my first attendance at an ICAP and I have been looking for the possibility to attend for several years. It was great to finally be able to share my research and to learn about many new topics in a community working exactly in my area; at the interface between geophysics and archaeology. Once again I realised that research involves a network of people and that a network needs a platform. I was overwhelmed by the feedback to my talk and was happy to become part of this community so instantly.

I once learned at another conference that on every conference day you should talk to three people you had never talked with before. I would like to pass this tip on to all, especially students and young scientists.

Doris Jetzinger, Bursary Recipient

"Oh my gosh, so many people, and I don't know any of them except for the other Austrian guys!" That was my first thought when entering the IT Sligo. My initial worries about not knowing people and the general challenges of social interaction were soon put to rest, though. Throughout the conference a very welcoming atmosphere prevailed and people were extremely nice and friendly - conference participants, organisers and not least the IT staff - which put me at ease fairly quickly.

This was the first conference I attended as a presenter rather than just as a visitor and it provided a completely new perspective and a lot of new experiences. And when I wandered around the poster boards during the coffee breaks, I was, admittedly, actually quite proud to see my own poster among all the others.

The best for me was certainly the inspiration I got from listening to all the presentations,

studying the posters, and talking to people. Everybody I met was more advanced than me in their studies or general academic career; however, in hindsight I feel this was really a great advantage for me as my brain has been in overdrive ever since, coming up with new ideas for a possible PhD project.

Everything - presentations, social events, the excursion on Sunday - was planned and scheduled perfectly and the organisers seemed to be very relaxed throughout. It all played a great part in helping me to enjoy myself. Therefore I would like to again thank all the organisers, my peer reviewers, all the extremely nice and friendly people I met during those five days in Sligo, and also of course the ISAP, whose support through a conference bursary made my participation much more manageable than it would otherwise have been. I am definitely looking forward to future ICAP conferences.

Ekhine Garcia, Bursary Recipient

Attending ICAP2019 in Sligo was a great experience for me. This conference is one of the reference points for people working in archaeological geophysics and attending the conference is a great way to find out about the state-of-the-art in the discipline. Some of the presentations inspired me to apply other data processing tools or complementary survey techniques that I had not integrated before in my daily work. The presented case studies were also useful for me, especially where archaeological verifications were shown that I could compare with similar cases so as to improve my interpretation skills.

Working in commercial archaeological geophysics, I see many projects and during

ithe conference I had the opportunity to share opinions and discuss specific cases with colleagues and to meet people for future research collaborations.

The conference was well organised with several social events that complemented the scientific program, in particular the ping-pong session. I really enjoyed spending time with other participants in an informal atmosphere.

Susan Curran, Bursary Recipient

ICAP2019 was a very positive experience for me, particularly learning more about different geophysical survey techniques and the ways in which they are being applied on a global scale. The technical papers gave insights into aspects of geophysical prospection with which I was not particular familiar. The Irish session on the first day was very informative as it demonstrated the different types of archaeological sites and the range of techniques being employed around my country. Interestingly, several international papers demonstrated the significant successes that can be achieved on similar monument types within a different setting. For example, the incredible results obtained from habitation sites in Iraq were on a strikingly different scale to those normally achieved in Ireland where houses are extremely difficult to identify due to different construction techniques, geology, monument survival etc. The underwater remote sensing papers were a particular highlight for me, especially as this field is somewhat underused in an Irish context. For example, the results from the investigation of Austrian pile dwellings demonstrated what can be achieved with appropriate technology and expertise.

On a personal level, coming from an archaeological rather than a geophysical sciences background, the opportunity to present my research to a different audience was particularly important, not to mention daunting. My previous presentations have been to audiences with a strong archaeological background or to community groups who wanted to learn more about the archaeology of their locality. Presenting my work to a highly experienced archaeological geophysics audience was quite challenging. Overall, I enjoyed the experience and came away with a greater understanding of the range of techniques in operation and their application on an international scale, as well as developments which will hopefully come into practice in the near future.

Ashely Green, Bursary Recipient

Being awarded an ISAP bursary allowed me to present my PhD research and gain feedback from experts in the field. The conference provided a wealth of knowledge from keynote speakers in Irish heritage and archaeology, and presentations from researchers and practitioners in archaeology, prospection and visualisation.

The conference presentations focused heavily on visualising, interpreting and presenting prospection data – from new artificial intelligence (AI) techniques for data interpretation to regional case studies and applications of prospection techniques. As a researcher in machine learning for data interpretation, an emerging topic in archaeological geophysics, the conference afforded opportunities to discuss approaches and methods with other researchers and commercial geophysicists with interest in the field. Melda Küçükdemirci's work on Semantic Segmentation of timeslices and my work on the use of Transfer Learning and Convolutional Neural Networks for the interpretation of graves in radargrams demonstrated the growth of, and interest in automated interpretation methods.

The social programme provided great networking opportunities and a chance to experience Sligo town and prominent archaeological monuments in Co. Sligo. The gala dinner and field trips to Carrowmore and Knocknarae were great opportunities to network with conference attendees and continue discussions in a relaxed atmosphere.

Dimitris Oikonomou, Bursary Recipient

ICAP2019 was a well-organised conference in the excellent facilities of IT Sligo. I truly appreciated the opportunity to attend such conference with numerous interesting oral and poster presentations, and the bursary from ISAP was really helpful for this purpose.

Kleanthis Simirdanis, Bursary Recipient

I had the opportunity to participate at the ICAP2019 conference at Sligo due to a bursary that was kindly awarded to me by ISAP. I am very thankful for that financial support since watching the latest pioneering work of many colleagues not only inspired me, but I was also given the chance to get to know many of them in person. Overall, the conference was a very well-organised event, fruitful and promising for future collaborations.

Forecasting surveys. A practical approach to predicting the impact of soil moisture on geophysical contrasts

ISAP Fund Completion Article

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For the archaeological surveyor, heat spells, hosepipe bans and consequent dry patches in lawns during the ever-hotter summers, followed by the upcoming fall inundations are stark reminders of the extreme forms moisture variations in soils can take on (what else is there to think about?!). Continually discussed at conferences, and often mentioned in survey reports, changes in soil moisture keep instilling uncertainty in electrical and electromagnetic survey datasets. It follows that the relationship between moisture balance and geophysical responses remain frequently investigated within and beyond archaeological applications, with some of the most well-known studies conducted in the framework of the AHRC-funded 'DART' project (e.g. Fry (2014)). Despite such concerted efforts, it remains difficult to capture the effect of moisture on electrical soil variations and, perhaps more importantly, predict the discrimination potential of specific geophysical instruments for archaeological contrasts.

The objectives of our study were to provide a straightforward method to evaluate the influence of moisture on electrical soil variations, using soil properties that can

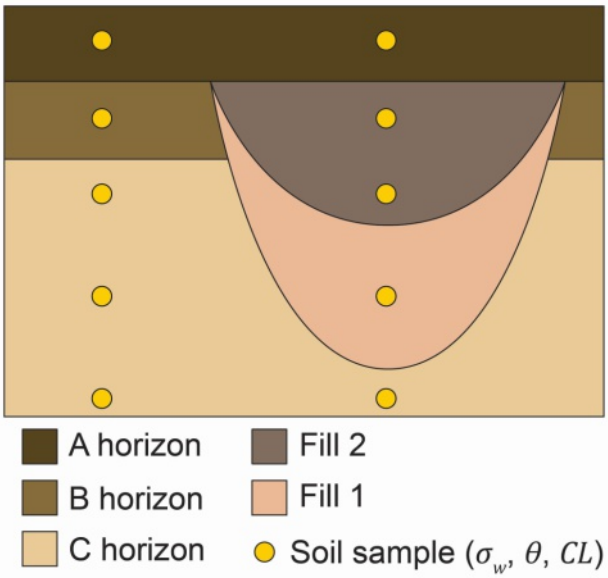


Figure 1: Schematic overview of a soil with a dug archaeological structure. In this example, the 'background' soil comprises three horizons, whereas the archaeologiical feature holds two fills with different properties than the surrounding soil. By determining the bulk density and clay content (and, if needed, soil water conductivity) the electrical conductivity for each sampled layer can be determined under varying moisture conditions. The latter is done by changing the gravimetric (and consequentially the volumetric) moisture content in the Generalized Archie's law.

easily be quantified through standard laboratory analyses. In addition, we focused on the impact of moisture variations on frequency domain electromagnetic induction (FDEM) surveys for which, to date, the influence of moisture remains much less explored than earth resistance and ground penetrating radar.

Theoretically, the method we propose builds on Archie's law, which describes the relationship between electrical conductivity of rocks and the material's porosity, cement fraction and water content (Allaby, 2013). To investigate unconsolidated sediments (soils), we use a modified version (Generalized Archie's Law (Shah and Singh, 2005)) that enables an evaluation of the influence of volumetric water content (θ), i.e. the gravimetric moisture content multiplied by the bulk density, the soil texture (or clay content CL) and the conductivity of the pore solution (σ_w), on the soil electrical conductivity. In this modified version of Archie's Law, the electrical conductivity of the solid matrix and the associated effect of the surface conductivity are integrated through fitting parameters related to the soil texture. More information on this empirical relationship can be found in Shah & Singh (2005).

By evaluating the properties detailed in Shah and Singh's Generalized Archie's Law for different layers on studied sites in both archaeological features and the undisturbed ('background') soil, the electrical conductivity of each sampled soil layer can be evaluated under different moisture conditions.

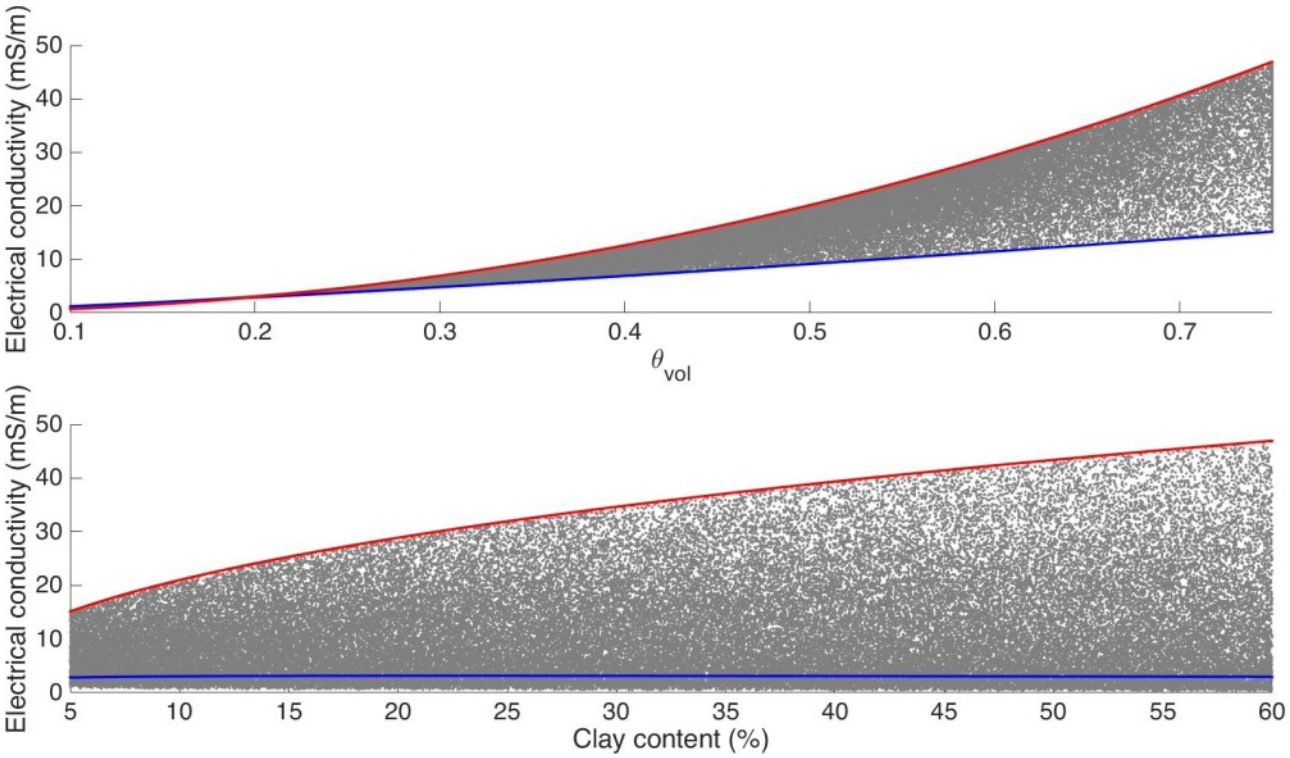
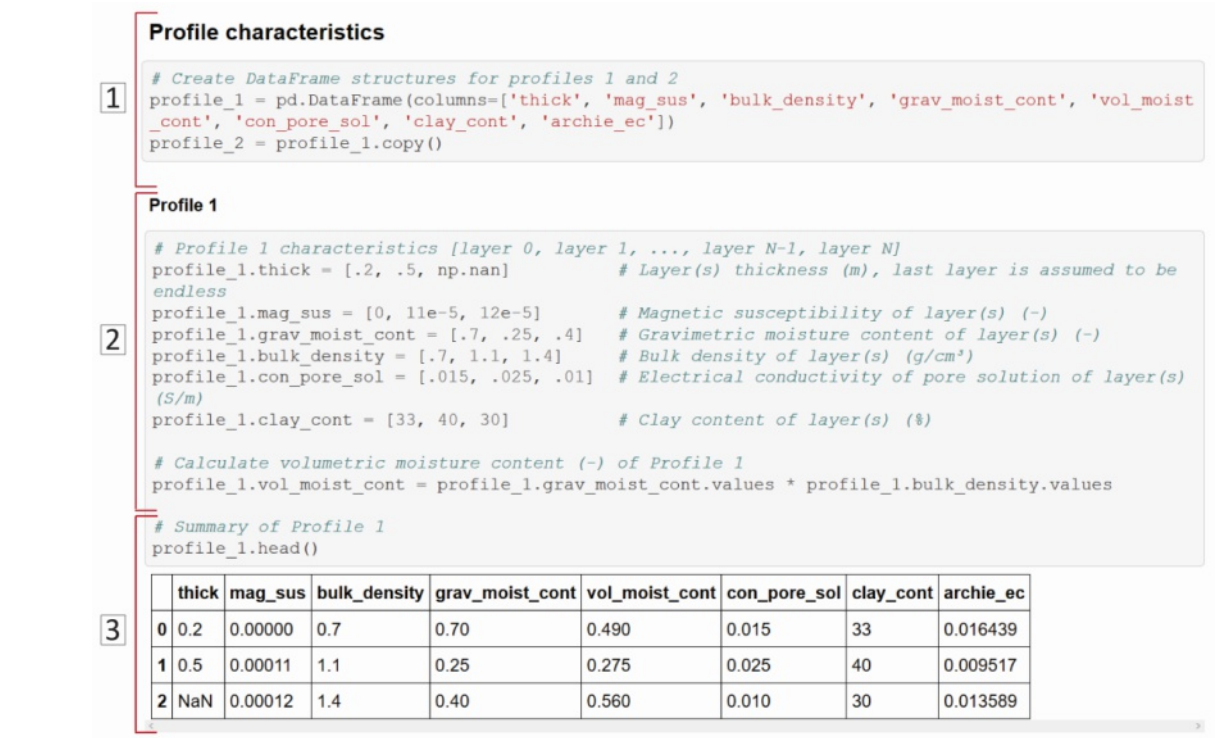


Figure 2: Random uniform Monte-Carlo sampling (100,000 samples) of the Generalized Archie's Law showing the electrical conductivity of a homogenous soil volume with changing volumetric moisture content (top), and at varying clay content (bottom). In the upper graph the blue and red lines represent changes at 1 and 60% clay content, respectively. In the bottom graph the blue and red lines indicate changes at 0.1 and 0.7 volumetric moisture content, respectively.

These electrical conductivities can then be integrated into forward modelling procedures to evaluate the apparent electrical conductivity (ECa) of the undisturbed soil profile and the profile obtained in the archaeological structure. By incorporating different volumetric moisture contents when determining the layer-specific EC, the ECa of such profiles can be evaluated under different moisture conditions.

We evaluated our approach synthetically, as well as in an experimental setting. Each time using the Generalized Archie's law to determine layer conductivities, and a 1D forward modelling (Ward and Hohmann, 1987) to evaluate the response of FDEM instruments (source-code can be found in Hanssens *et al.* (2019) and the associated Github repository http://github.com/dhanssens). Performing a sensitivity analysis (Monte Carlo simulation) allows an evaluation of the influence of the sampled soil properties on the soil electrical conductivity of the evaluated layers. You can see how, following the Generalized Archie's law (Shah & Singh, 2005), the electrical conductivity of a homogenous soil volume is influenced by changes in moisture content and soil texture (i.e. clay content). The soil electrical conductivity increases exponentially at increasing moisture content, whereas a



Profile characteristics

1
```
# Create DataFrame structures for profiles 1 and 2
profile_1 = pd.DataFrame(columns=['thick', 'mag_sus', 'bulk_density', 'grav_moist_cont', 'vol_moist
_cont', 'con_pore_sol', 'clay_cont', 'archie_ec'])
profile_2 = profile_1.copy()
```

Profile 1

2
```
# Profile 1 characteristics [layer 0, layer 1, ..., layer N-1, layer N]
profile_1.thick = [.2, .5, np.nan]          # Layer(s) thickness (m), last layer is assumed to be
endless
profile_1.mag_sus = [0, 11e-5, 12e-5]       # Magnetic susceptibility of layer(s) (-)
profile_1.grav_moist_cont = [.7, .25, .4]   # Gravimetric moisture content of layer(s) (-)
profile_1.bulk_density = [.7, 1.1, 1.4]     # Bulk density of layer(s) (g/cm³)
profile_1.con_pore_sol = [.015, .025, .01]  # Electrical conductivity of pore solution of layer(s)
(S/m)
profile_1.clay_cont = [33, 40, 30]          # Clay content of layer(s) (%)

# Calculate volumetric moisture content (-) of Profile 1
profile_1.vol_moist_cont = profile_1.grav_moist_cont.values * profile_1.bulk_density.values
```

3
```
# Summary of Profile 1
profile_1.head()
```

	thick	mag_sus	bulk_density	grav_moist_cont	vol_moist_cont	con_pore_sol	clay_cont	archie_ec
0	0.2	0.00000	0.7	0.70	0.490	0.015	33	0.016439
1	0.5	0.00011	1.1	0.25	0.275	0.025	40	0.009517
2	NaN	0.00012	1.4	0.40	0.560	0.010	30	0.013589

Figure 3: Section of the online tool where profile information can be entered. In [1] data frames are generated to allow transferring profile information into the forward modelling procedure. In [2] profile information derived from in-situ observations can be entered: for each layer the clay content, bulk density and thickness (with last layer thickness set to infinity) can be entered as observed variations, along with the magnetic susceptibility and the (observed or estimated) conductivity of the pore solution. The gravimetric moisture content can then be entered as observed in the field, or different values can be entered to evaluate impact of the moisture content on the layers' conductivity. In [3] the layer properties are tabulated, along with their electrical conductivities determined by the Generalized Archie's law.

more gradual increase is caused by changes in clay content. If we investigate the influence of soil moisture on a non-clayey soil (i.e. clay content below 5%), we see that soil moisture still has a strong effect on the electrical conductivity. Represented in Figure 2 by the lines, the total variation in electrical conductivity of a homogenous volume that can be attributed to changes in moisture content (i.e. irrespective of changes in clay content and pore solution conductivity) has a range of 22 mS/m. This is, of course, a synthetic model of a homogenous soil volume that evaluates moisture variations from 0.10 to 0.75, but even for realistic changes in soil moisture the influence of soil moisture remains strong. When considering soil moisture variation between 0.30 to 0.60, for instance, this results in an electrical conductivity change of 6 mS/m (from 5 to 11 mS/m at 0.3 and 0.6 moisture content, respectively), all excluding the influence of changes in clay content or in the conductivity of the pore solution. These relationships are of course inherent to the applied version of Archie's law as presented by Shah and Singh (2005), but nonetheless such simple sensitivity analyses enable a clearer grasp of the influence of moisture variations.

By incorporating the properties of different soil layers a synthetic model can be created of a soil profile upon which varying moisture balances can be simulated. In the online tool we have developed for this, this is done by entering the number of soil layers, each layer's volumetric moisture content, its clay content and the conductivity of the pore solution. In addition, as we approach this from the

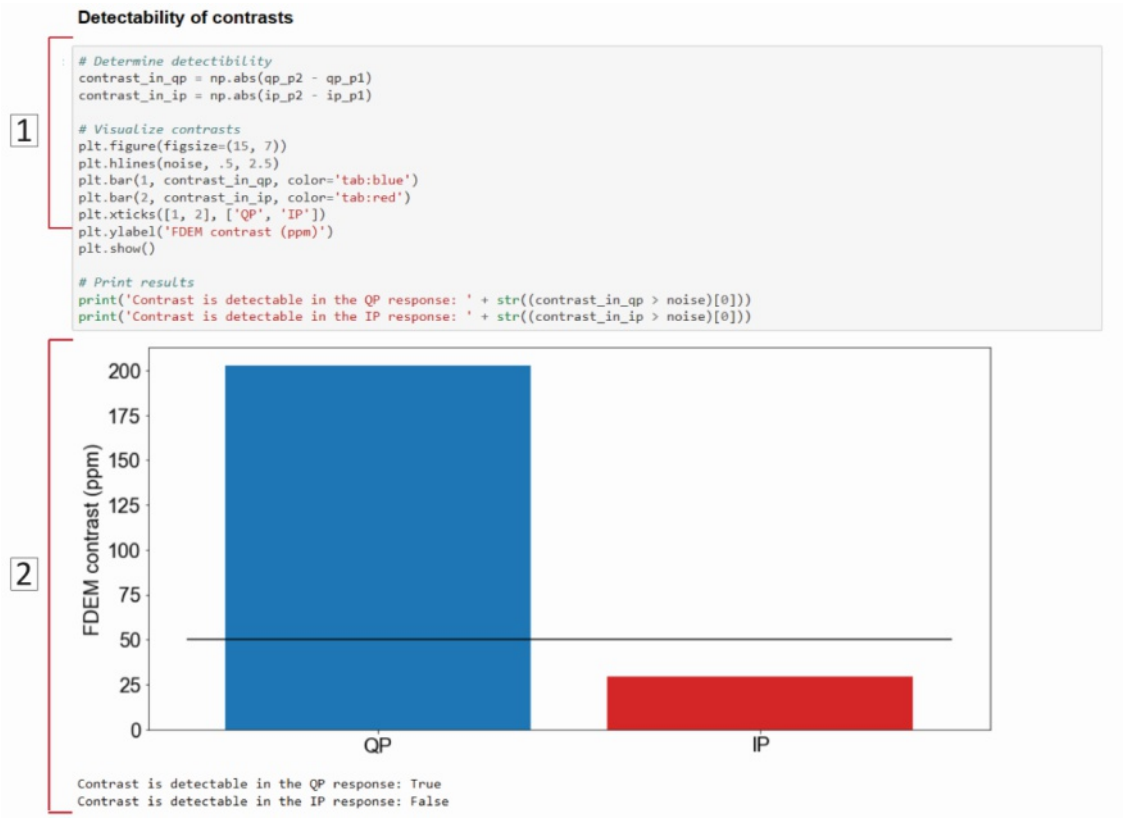


Figure 4: Part of the online tool where electromagnetic contrast between two known soil profiles is evaluated. In [1] the difference in response between the two profiles is calculated, and the parameters are set. In [2] the contrast is shown for the QP and IP response of the given FDEM configuration. The instrumental noise level is indicated by the black line.

perspective of FDEM surveying, the magnetic susceptibility of each layer can be indicated as well. In the online tool this information can be entered in the subsection 'Profile characteristics' (Figure 3).

When information of two soil profiles is given (i.e. of the undisturbed soil background and the section of an archaeological feature) the conductivities of layers in these profiles can be evaluated under different moisture conditions. In our study the effect of such changing moisture conditions was evaluated for FDEM surveys. The forward model therefore enables an evaluation of the contrast between the two given soil profiles in the in-phase (IP, broadly proportional to the soil magnetic susceptibility) and the out-of-phase (quadrature phase or QP, broadly proportional to the soil electrical conductivity) response. The properties of the used instrument can be entered into the online tool to test different types of coil geometries and operating frequencies. In the example presented here, we evaluate responses obtained with a FDEM instrument that operates at a frequency of 9,000 Hz and has a horizontal coplanar coil configuration with a 1.0 m transmitter-receiver separation.

The tool outputs the contrast in relationship to the instrument's noise level, stating that the electromagnetic contrast rendered by the investigation profiles is

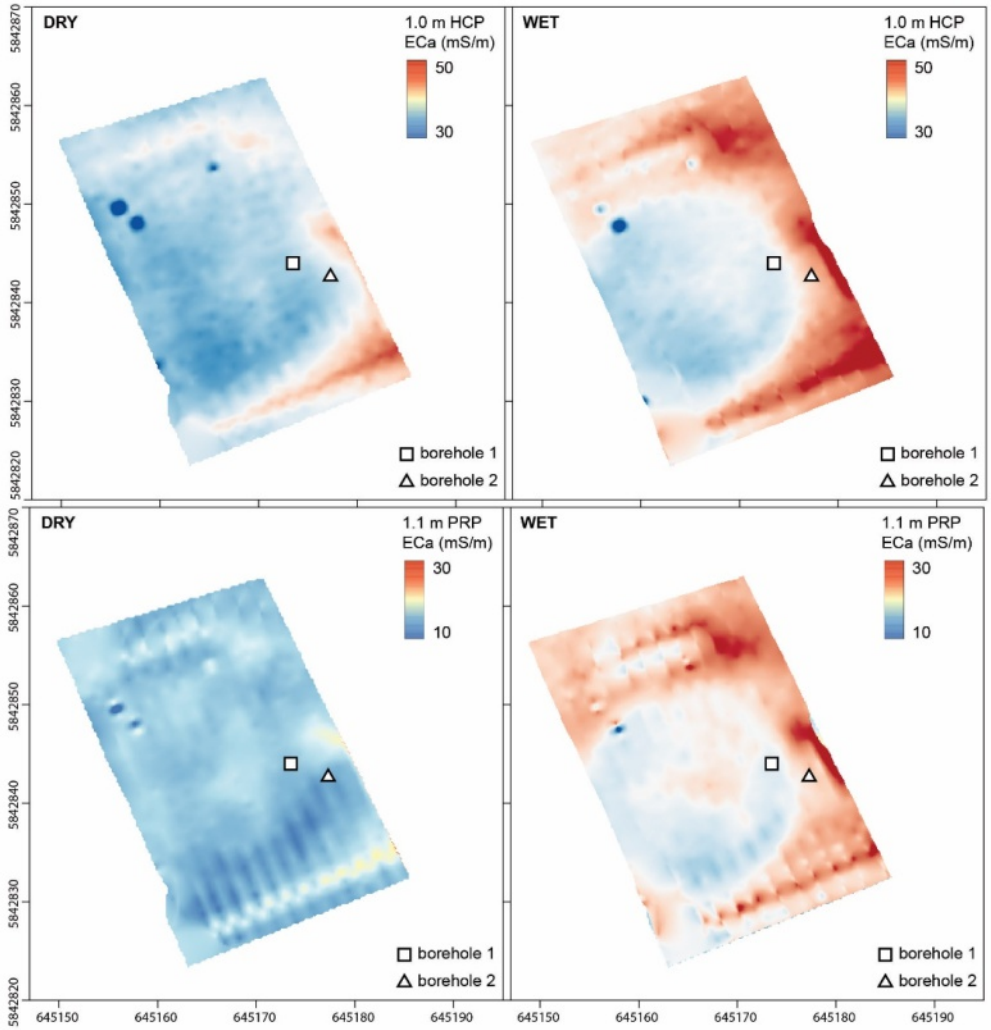


Figure 5: Comparison between data collected under dry (October 2018) and wet (January 2018) conditions. Showing the coil pairs rendering the strongest contrast: 1.0 m HCP (top) and 1.1 m PRP (bottom).

detectable when it exceeds this level. In Figure 4 a contrast is detected between evaluated soil profiles in the QP response. In other words, the change in conductivity between the two soil profiles has no influence on the IP response (which in this case remains determined primarily by the moisture-independent soil magnetic susceptibility), but causes a significant difference in the QP response. The archaeological feature simulated in this example can therefore be detected with the modelled FDEM instrument if the average soil moisture content is 0.75. When this moisture content decreases to 0.50, however, a contrast can no longer be observed with this specific coil configuration.

We evaluated the validity of this procedure on a real-world case and investigated the influence of moisture variations on archaeological structures on a wetland area in Wervershoof (NL) with known, ploughed-out Bronze Age burial mounds (van der Heiden *et al.*, 2018). One such mound was surveyed and sampled under wet and dry conditions to test the synthetic procedure. Figure 5 shows the electrical survey data (QP i.e. ECa) and borehole sampling points where soil samples were obtained to evaluate clay content, bulk density, moisture content and the conductivity of the pore solution.

The soil composition of the sampled profiles ranges from loam to silt loam (clay content from 9 to 18%) in the barrow mound (borehole 1), and from silty clay to loam (clay content from 12 to 48%) in the surrounding background soil (borehole 2). In the surrounding soil, texture is more fine grained in the upper layers (silty clay to clay loam), whereas the clay content drops to 12% (loam) from a depth of 0.5 m onwards. The average gravimetric moisture content throughout the soil profile under dry conditions was 22%, whereas under wet conditions this was 41%. It is important to note that this difference mainly occurs in the upper soil layers, under the influence of rainfall. The gravimetric moisture content of the upper

Table 1: Overview of the observed and modelled FDEM responses and contrast detectability of the two soil profiles at Wervershoof. For each profile the measured and modelled responses, as well as the absolute contrasts are shown in ppm.

	1 m HCP							
	Dry				Wet			
	Measured		Modelled		Measured		Modelled	
	QP	IP	QP	IP	QP	IP	QP	IP
Profile 1	646	800	89	28	690	670	137	27
Profile 2	664	800	79	19	790	680	241	22
Absolute contrast	18	0	10	9	100	10	104	5
Detectable?	No	No	No	No	Yes	No	Yes	No
	1.1 m PRP							
	Dry				Wet			
	Measured		Modelled		Measured		Modelled	
	QP	IP	QP	IP	QP	IP	QP	IP
Profile 1	300	180	76	-29	379	390	172	-29
Profile 2	270	170	83	-20	505	350	280	-20
Absolute contrast	30	10	8	9	146	40	108	9
Detectable?	No	No	No	No	Yes	No	Yes	No

0.15 m in wet conditions ranges from 44 to 78%, whereas in dry conditions this varies between 26 and 32%. If we reproduce this variation synthetically, we see that the observed contrast in the field is overall predicted accurately in the simulation (Table 1).

By collecting information on relevant soil properties, and conducting FDEM survey under different moisture conditions, we aimed to develop a procedure to predict the contrast of archaeological features in both the QP and IP response as recorded by FDEM instruments.

Based on the conducted FDEM measurements and analysed soil samples we were able to evaluate the efficiency of this procedure to provide a reliable assessment of varying electrical contrasts under changing moisture conditions. While the procedure in most cases allowed accurate reproduction of the contrasts observed in the FDEM surveys conducted under both dry and wet conditions at the site of Wervershoof, a discrepancy exists in the obtained absolute values. At Wervershoof, this resulted in an overestimation of the absolute modelled FDEM responses compared to the observed in-situ variation. This inconsistency is related to a stacking of multiple errors: the influence of relative calibration of FDEM measurements (Delefortrie et al., 2014); effects of anisotropy on the measured responses as opposed to 1D modelled responses (Tølbøll and Christensen, 2007); the inherent simplification of assumptions (linearity) in the Generalized Archie's Law (Shah and Singh, 2005); theoretical simplifications in the 1D FDEM forward model (Ward and Hohmann, 1987) and errors in the measured soil parameters.

Although the presented work is a small-scale study, it shows how by integrating in-situ observations of specific soil properties with observed and modelled geophysical responses can help predict and explain mapped geophysical variations. More than providing precise replications of geophysical variations the purpose of the procedures as presented here is to provide surveyors and archaeological end-users with straightforward tools that help them understand the potential and limitations of archaeogeophysical prospection. While, particularly when addressing complex problems such as moisture influence, these simplified models of the subsurface should be used with caution and only as part of a larger toolkit, we hope they will help to close the gap between theoretical studies of work in soil science and geophysics, and the practical use of geophysical methods in archaeology.

Acknowledgements

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First SAGA Training School: Introduction to the Use of Geophysical & Soil Science

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COST Action SAGA is an EU-funded interdisciplinary network of scientists that aims to develop, promote and facilitate scientific activities bringing together archaeo-geophysics and soil science with the overall goal of maximising interpretation of proxy data for archaeological investigations. As part of its training remit, the first Training School (TS) was held at the archaeological site of Zaldua, Spain, from 29 July until 2 August 2019. The theme was the "Introduction to the use of Geophysical & Soil Science methods in Archaeology". Being the first Training

Figure 1: Participants and trainers during the hands-on session on site.

School, it was designed to be on an introductory level. The main objectives were to explain fundamental concepts and provide a clear methodological understanding of routine geophysical and soil science methods used in archaeological investigations.

The TS was addressed to Master students, PhD candidates, postdoctoral researchers, field archaeologists, curators and other professionals working in cultural heritage management with none or little knowledge of those techniques. In order to provide practical experience, theoretical sessions were complemented with hands-on sessions at the archaeological site of Zaldua.

This site has previously been surveyed using geophysical and geo-archaeological methods (Garcia-Garcia *et al.* 2015, Garcia-Garcia *et al.* 2016, Garcia-Garcia *et al.* 2017), making it an ideal place to host this training school. Zaldua is located in the north-east of Navarre, between the cities of Auritz/Burguete and Aurizberri/Espinal, and may be the ancient town of Iturissa described by Ptolemy in the 2nd century AD. This area lies on the southern side of the Pyrenees range, in a natural pass through the mountains. The magnetometer survey had already provided a detailed plan of the layout in the main area revealing a town organised along the Roman road that continues to the north through the Pyrenees (Garcia-Garcia *et al.* 2016). These results had been used to guide further investigations using complementary geophysical and geoarchaeological surveys (Garcia-Garcia *et al.* 2017). From 2015 excavations were undertaken each summer, directed by

Figure 2: Poster session with flash presentation.

Aranzadi Society of Science and supported by the Museum of London Archaeology (MOLA). These provided feedback for a nuanced understanding of the geophysical results.

The TS received 52 applications mainly from PhD students, but also from master students, researchers and professionals. Out of these 21 trainees from 12 affiliation countries were selected and joined the TS together with 11 trainers from 6 different countries (Figure 1). All trainees obtained a SAGA Trainee Grant, which is a contribution to the overall travel, accommodation and meal expenses.

The Training was spread over five days. The first was dedicated to introductory concepts. In addition, trainees were asked to bring a poster summarising their own research activities and presented these in a poster-flash session (Figure 2). During the second and third day, archaeo-geophysical methods were explained and complemented with hands-on sessions, and archaeo-geophysical data processing and geochemical methods were introduced. The fourth day was set aside for data acquisition at the archaeological site. Trainees were divided into groups and attended four stations: ground-penetrating radar survey (Figure 3); electrical resistivity tomography; physico-chemical measurement of sediments in

Figure 3: GPR survey during the hands-on session at the archaeological site.

the sections of the open archaeological trench using pXRF and magnetic susceptibility (Figure 4); and core drilling for sediment and stratigraphy characterisation. On the last day parallel sessions were organised to address the different interests of trainees in more detail. The formal part of the TS was then completed with a presentation of the new geophysical and physico-chemical data that were acquired during the TS followed by an informal session where all trainers and trainees could comment on the data. The TS was closed with a guided visit to the historic city Iruñea/Pamplona.

Figure 4: Hands-on with pXRF and magnetic susceptibility on the open section.

Zaldua proved to be a perfect site to host the TS given the previous archaeological, geophysical and soil research that had already been undertaken. This provided a broad context to illustrate the application and complementarity of different disciplines and methods, as well as to interpret the new data collected. In addition, some areas in Zaldua pose difficulties in terms of their archaeo-geophysical interpretation. These were used to challenge the trainees in archaeo-geophysical interpretation as well as discuss and show-case solutions. According to the trainees' feedback survey, the TS was excellent (75%) or very good (25%) and highly recommendable (94%), and overall, a highly satisfactory experience for all those involved.

About SAGA

SAGA is funded by the European Cooperation in Science & Technology (COST) for four years (26th October 2018 - 25th October 2022). The alliance brings together geophysicists, archaeologists, soil scientists, geologists and a wide range of experts

in other geoscience sub-disciplines coming from research, commercial and cultural heritage management institutions.

The alliance is structured into four Working Groups (WG) that focus efforts to achieve a number of specific scientific tasks. The objectives and tasks of these WG are described in SAGA's published proposal (Cuenca-Garcia *et al.*, 2018). Each WG is coordinated by a WG Leader and the project overall is managed by a Management Committee (MC) composed of members nominated by COST countries which are signatories of SAGA.

In order to achieve SAGA's objectives and tasks, the alliance makes use of a range of networking tools available for all funded COST Actions (e.g. management meetings, workshops, conferences, short-term scientific missions-STSM, training schools and conference grants). You can keep updated on SAGA activities and funding through its website (https://www.saga-cost.eu/) or by following it on Facebook (https://www.facebook.com/SAGACOST/), Twitter (https://twitter.com/SAGA_COST) and ResearchGate (https://www.researchgate.net/project/COST-Action-SAGA-the-Soil-Science-Archaeo-Geophysics-Alliance-going-beyond-prospection).

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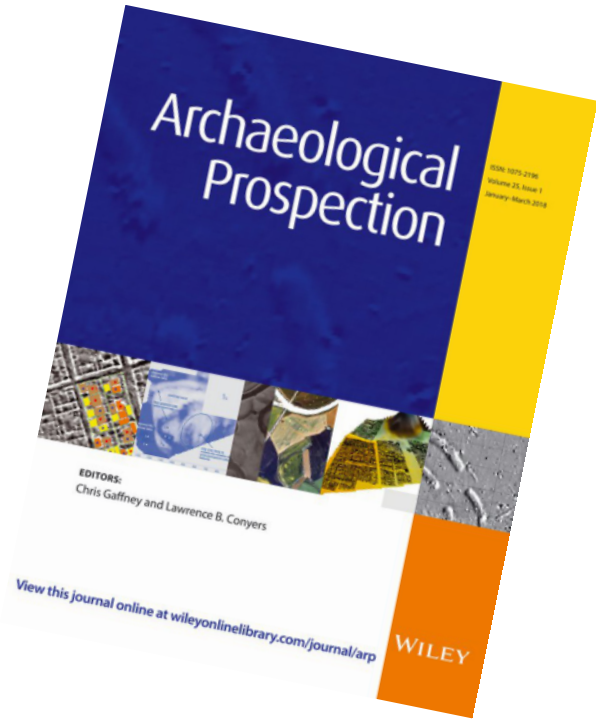

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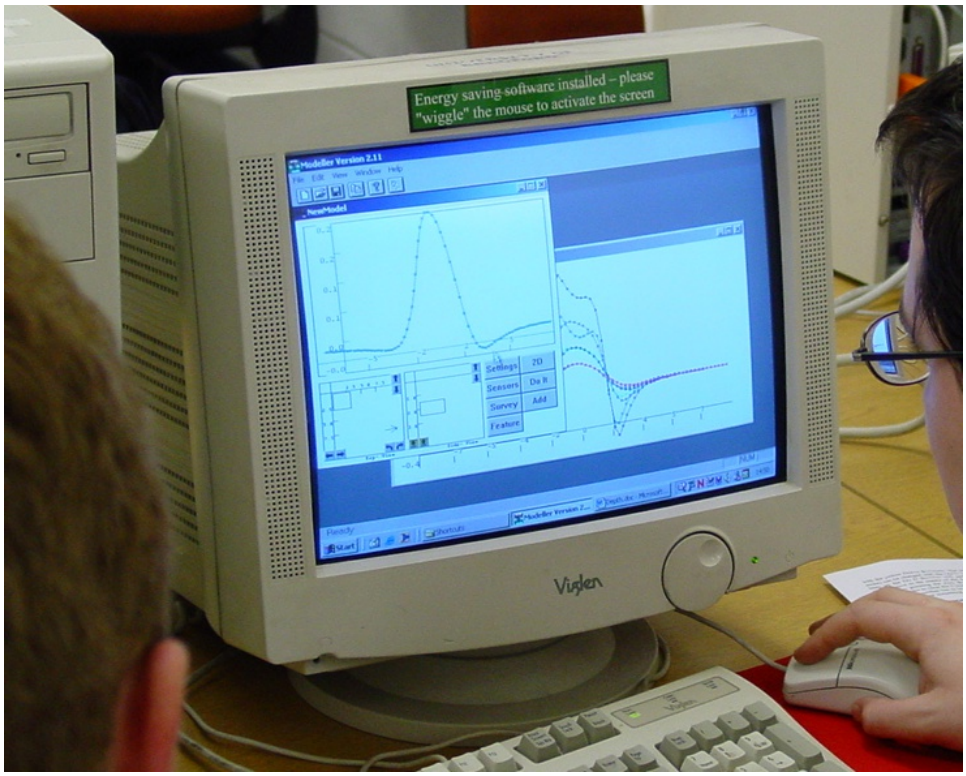

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