

## Mastering Metals | EXARC

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### Guests

Fergus Milton (UK) and Giovanna Fregni (CY)

### Introduction

The use of metal has transformed almost every aspect of life, helping us to clothe ourselves, create cars, trains and planes, get to the bottom of the ocean and out into space. On this month's episode of Finally Friday, we take a look at how experimental archaeology helps us to understand metal in the past, with guests Fergus Milton and Giovanna Fregni. Fergus Milton is a long-standing prehistoric metalworking demonstrator at Butser Ancient Farm in the UK. He works closely with the public, giving frequent demonstrations of his work. Giovanna Fregni is an experienced jeweller and archaeologist with particular interests in non-ferrous metals and replicating ancient metalworking techniques from the Bronze Age to Medieval period. Similarly to Fergus, she now offers demonstration and teaching on these ancient techniques.

### Transcript

It's the first Friday of the month, which means that it's time for the next episode of #FinallyFriday, bringing you insights and discussions from around the world focussing on experimental archaeology, ancient technology, archaeological open-air museums and interpretation.

**Phoebe:** Hello and welcome to Finally Friday. My name is Phoebe Baker and today I'm joined by two specialists from our EXARC community focussing on ancient metalworking.

Fergus Milton is a longstanding prehistoric metalworker demonstrator at Butser Ancient Farm in the UK. Having been involved in experimental metalworking since the early 2000s, Fergus has developed a particular interest in smelting, principally of copper ores, although also delving into other metals such as tin, lead, brass and occasionally iron. In his demonstrator role at Butser Fergus works closely with the public, offering demonstrations and occasional teaching of these fascinating skills.

Giovanna Fregni is an experienced jeweller and archaeologist with particular interests in non-ferrous metals and replicating ancient metalworking techniques from the Bronze Age to medieval periods. She particularly enjoys reconstructing hammers, anvils and other tools to understand metalworking technologies. She has also contributed to research on the preservation and reconstruction of archaeological metal and currently Giovanna travels significantly, offering demonstrations and teaching on these ancient metalworking techniques.

So a big welcome to both of you and thank you so much for joining me. I'm sure it's going to be a great conversation. I have a pretty big question, I think, to start you off and it's: why is ancient metalworking important? Fergus, would you like to go first?

**Fergus:** Yeah, sure. I suppose because without it, the world we live in would be very, very different. Having metal has let us get to the bottom of the ocean and out into space, but if you didn't have metal, you wouldn't have internal combustion engines and no planes, trains and automobiles, much smaller buildings, much smaller ships. The world would be unimaginably different if we didn't have metal.

**Giovanna:** Another significant thing about ancient metalworking in particular is that with the advancement of technology, some of the older technology gets lost. One of the articles I had published with EXARC was about how much tin was lost in recycling bronze, because in a modern furnace, using a gas or an electric furnace, you always have some of the tin just burns out, it oxidises, so you have to keep adding it every time you recycle bronze. So I went out to experiment and figure out how much tin was lost, figuring that that would be a good calculation for how much tin was needed in the Bronze Age. But when you use a charcoal fire, it's so reducing that no tin is lost. You can recycle bronze axes in a charcoal furnace forever and never have to add tin to it. So it's things like that that getting back some of the technology and techniques that were lost is also an important thing.

**Fergus:** That was a really brilliant paper because I'd always come at it with modern knowledge, assuming that tin would be lost when you were remelting bronze. So when I read your paper, it was a real eye-opener, so well worth looking up if people can find it.

**Giovanna:** It's on the EXARC website, in the journal.

**Fergus:** I was just going to say on the ancient metalworking as well, so many of the tool designs that we use today all go way back into antiquity. Years ago, I found my favourite ever bronze item in the British museum, which is a hacksaw blade. Essentially, it's a saw blade with a hole at each end for mounting on a frame. And somebody came up with that idea thousands of years ago and we've just been copying it ever since. And it's the same with so many of the classic tool designs, isn't it?

**Phoebe:** They were some really great answers, thanks. To pull it back a little bit to yourselves and I think I touched on this slightly in the bio for each of you but I wanted to ask what are your favourite metals to work with?

**Giovanna:** When I was a jeweller, I liked working with gold because it was so easygoing and nice to work with, but always out of my price range, so I could never experiment with it. But I like working with silver and bronze. Pure copper tends to be a bit of a pain, but it's all good. It's all fun. I've done some iron smelting, but you don't get the immediate satisfaction that you do with non-ferrous metals.

**Fergus:** For me it would be the copper as well. I certainly echo what you're saying because trying to cast in copper is quite difficult. There's more of a surface tension on it, but I love the colour of copper even more than bronze, I think. And I also really like working with tin because it's just such a beautiful metal and it's got some funny little properties. Like it creaks and cracks when you bend ingots of it. It just melts from solid to liquid so easily. It's just magical to watch.

**Giovanna:** Tin is really good when I demonstrate for kids because in a short amount of time you go from solid to liquid to solid again. Even if you've got hordes of kids coming through, classroom after classroom, you can demonstrate it with tin where with bronze it would take a little longer.

**Fergus:** It's quite a good one for people to practise with as well if they've never poured molten metal before. Because as you say, it's so easy to melt and just get the feel of what it's like to pour out liquid metal.

**Phoebe:** Yeah, I think I've done some of those days in the past where you see demonstrations and things and had a go at some tin melting myself and it is really magical how quickly it melts and how easily you can change its form. So you've mentioned a little bit about your techniques that you use and you mentioned words like casting and smelting and pouring. As somebody who - my interests are in the Paleolithic, there's no metal involved at all - would one of you mind explaining what exactly you mean by these terms?

**Giovanna:** Smelting is extracting the pure metal from an ore or as pure as you can get it. Casting, we're talking about taking the metal or an alloy and pouring it into a mould or doing something with it, casting it, melting it, pouring it, but it's already ready to go.

**Fergus:** The other way I describe it to people is that casting is something you can do again and again using the metal you've already got. You can melt something down and cast it back into a different item, whereas smelting is a one way irreversible process. You start with rock, you end up with metal and no matter how long you leave it, it's never going to go back into the rock form again. It can get a little confusing with copper in particular because if you've got a copper roof you get the oxidation happening and you get the verdigris on it and it looks a little bit like malachite, one of the rocks that you can get copper from, but it's never ever going to change back into it again. It really is a one way process and that's why I like it. It's just such a magical dose of alchemy, I guess, for want of a better description.

**Giovanna:** Yeah, smelting copper I think that's the most fun of all metals to extract.

**Fergus:** Yeah, certainly agree with you there.

**Phoebe:** Why is that?

**Giovanna:** The easiest one to do is to smelt as malachite. So you've got a green rock that a lot of people are familiar with from jewellery and there's various ways you can smelt it, but when you're done, you've got shiny metal. The green is all gone. It's just transformative.

**Fergus:** Going back to a thing you were saying just now, Phoebe, a lot of malachite is sort of copper, about 58% and then the rest of it is mainly water and oxygen and you'll get trace amounts of other things, but you essentially make it all disappear. You lose the oxygen into the fire, you lose the water into the fire and you're just left with that lovely shiny metal. And when you're doing the smelting and particularly if you do it in the dark or inside a building or something like that, you get these vivid emerald green flames a lot of the time and they're just quite magical to see.

**Giovanna:** Yeah, there's no yellow in the flame. It's not like a gas flame where you've got some blue and some yellow. The entire flame changes colour and it's very strange-looking. Fire is not supposed to look like that.

**Phoebe:** That sounds really cool. And can we see evidence of this in the archaeological record and when is the first evidence of people smelting copper ores?

**Fergus:** It is maybe useful to step back a little bit there and just explain you can actually find some metals in a form that's ready to use straight away, what's known as native metal. The example most people are familiar with is something like a gold nugget, which actually is gold. It's already gold. You don't need to convert it or anything. And if you were lucky enough to find a gold nugget, you just need to use maybe stone tools or something like that to shape it into whatever you wanted, but you wouldn't need to do any conversion because it already was gold. In antiquity our ancestors had access to native gold, silver and platinum, which are all sort of decorative metals. You can't really do functional things with them like axes and knives and stuff like that particularly, but you can also get native copper. What do you think, Giovanna, would you say that meteorites are an example of native iron?

**Giovanna:** It's kind of hard to call it native iron because it's not from here, but it is a pure iron that you can work. So it fills half the definition.

**Fergus:** Yes!

**Giovanna:** The part of the United States that I've come from in Minnesota has a lot of native copper. You can still find it up there. The Native Americans of the late Archaic worked it into amazing things. They did spearheads, sheet metal work, ornaments, digging tools, all without fire. They could anneal it, but they couldn't melt it. They didn't have any ceramic technology or high fire technology. So everything was done by hammering, pounding, they pounded it into wooden forms or maybe stone moulds, but it was all mechanical.

There was no casting involved.

**Phoebe:** Wow, that's fantastic!

**Fergus:** I think the way you can tell native metal, if it hasn't ever been melted by humans, is that when you look at it under a microscope, it's got large crystals in it. So when something is normally solid but you've made it liquid, when it starts cooling and turning back into a solid, that's through crystallisation.

Native metals tend to have quite large crystals in, presumably because the cooling happened very, very slowly. Whereas if Giovanna and I were taking a crucible of molten metal out of a furnace, it would be solid in under a minute most of the time, well under a minute. So the crystals in there would be very small. When people looked at the very early tools and weapons that people have made from things like copper they've got these large crystals that point towards it being native copper that's been used rather than copper produced by the smelting process from rock.

**Phoebe:** I see. That was really interesting to bring up. It reminds me of things like the knife found in Tutankhamun's grave. That was meteoric iron, wasn't it?

**Giovanna:** Yeah.

**Phoebe:** Very cool. So, we've talked a little bit about smelting, but I know that you both have been involved in casting as well before. What are some of the techniques that you can use for casting? I presume it allows you to make pretty fancy objects if you want to.

**Giovanna:** Where to start? I think we've both used stone moulds, replicas of stone moulds and clay moulds and lost wax. There's all sorts of ways to make a mould to cast into. Sand moulds that leave absolutely no archaeological traces. Once you're done with a sand mould, everything has disappeared. But you do find fragments of ceramic moulds. People also made moulds of bronze that they cast bronze into.

**Fergus:** Is that something you've done? I've never done that myself.

**Giovanna:** I've used other people's bronze moulds and they work beautifully. The only problem is that you have to take the object out right away because bronze shrinks, just about any metal shrinks as it cools. So it's not a concern if you're using a clay mould, but when you do use a stone mould or a bronze mould, you have to take it out pretty quickly or else it's going to bind right into that mould. Unless it's something very simple like an arrowhead without any loops or anything on it.

**Fergus:** That's something I've always wanted to try but I've never made any myself or used anyone else's.

**Giovanna:** We'll have to get together and try it.

**Fergus:** I'll come to Cyprus.

**Giovanna:** Oh yeah, you've got to come here. It's the origin of copper. The island's name, Kibris/Kýpros, it's the root word for copper.

**Fergus:** I think you've used cuttlefish as well. I use it quite a lot, but you've used it as well.

**Giovanna:** Yeah, I've even used cuttlefish that I found on the south coast of England. So there's a possibility that people back in the Bronze Age would have used it for casting moulds too.

**Fergus:** I learned recently, I hadn't appreciated this, that there's actually a good season for getting cuttlefish and a kind of off season because they breed and die in the springtime. I went to the beach recently and I was very disappointed not to find any at all. So I'm kind of stuffed until next year when there's some more out there.

**Phoebe:** How do you go about using cuttlefish as a mould? It might just be me, not knowing much about metal, but it sounds interesting.

**Giovanna:** Cuttlefish bones are the sort of thing you have in bird cages for birds to chew on. They're white oval things and they're pretty much pure calcium carbonate so they're very soft. You can carve it with your fingernail. So just flatten a couple of pieces so that you can tie them together and then use whatever tool you want to carve a shape. Make a little pouring cup and you're good to go.

**Phoebe:** Are they fragile at all? Does it restrict what kind of metals you can use or is it applicable to anything?

**Giovanna:** If you're casting tin or pewter you can use it over and over again if you're careful. But the bronze burns it out, so it's a one time only cast.

**Fergus:** It also stinks like crazy as well. You get a real smell of burnt fish when you use them.

**Phoebe:** Does the smell go away if you use it over and over again, or does it stay every time?

**Fergus:** It gets less, I find, with time but most of the time I use them for bronze so they are one use only. There was a visitor at Butser Ancient Farm where I do stuff the other day and he's a modern goldsmith, but he does exactly the same. He goes to the beach and he gets them and he uses those for making his modern gold items. So it may be ancient technology, but it's still in use today by people as well.

**Giovanna:** I was going to say that when you start out in jewellery school they start you out with cuttlefish for making moulds, learning to make moulds and do some casting.

**Phoebe:** Wow, that's really cool. And that brings me on to another question. You mentioned that you started in jewellery school and Fergus, I believe that you are self-taught in metalworking. How do you think that influences how you both approach metalworking? Do you think it gives you both different perspectives or do you think you come to similar conclusions anyway?

**Fergus:** I wish I had some of the formal training that Giovanna's had, because I think that would be extremely useful. The only real formal training I had when I was at school we did sand casting of aluminium, or aluminum if you prefer, and that was the only sort of formal training I had. So there's times when I wish that I'd done more courses and things. I am going off to learn enamelling in January next year. It would be good sometimes if I'd done a bit more training and had that to call on. So I basically just sort of blunder my way through and probably make a lot more mistakes than I would do if I had some training behind me.

**Phoebe:** Do you think that ever those mistakes have led you on to things that you might not have got to if you had had the formal training, or do you just think it would have been useful to have the training?

**Fergus:** I think it's useful to just try things out. There's been a long-running argument at Butser because some of the people who set it up in the first place came from a pure scientific background. And so they wanted everything to be done as a sort of pure experiment. Sometimes it's fun just to play with stuff and just see what happens.

And then maybe go back and do a proper scientific experiment afterwards. But sometimes it's just fun to cut loose and try things out with no idea how it might turn out.

**Phoebe:** Yeah, that's fair enough. Interesting that those same conversations are happening at an organisation like Butser.

**Fergus:** It is a wonderful place to do stuff like that because you can have fires of any kind anywhere and it's unusual to have access to that sort of facility, so it's great for doing experiments and just trying things out.

**Phoebe:** Yeah, I can imagine. Did you want to add anything, Giovanna?

**Giovanna:** I was going to say that, coming from somebody who had formal training in metalsmithing and jewellery-making, when I first started reading stuff written about archaeological metals I was getting very frustrated and tearing my hair out because so much of what was written was just wrong. It was written by academics who had never held a tool in their lives. They were writing about metalsmithing and the mistakes made from assumptions about how things were done were just being repeated by other people over and over again until it kind of became established fact when it wasn't.

**Phoebe:** Yeah, that's a great point to bring up and I know that we talked a little bit about this beforehand. Which leads me into another question of being: how has the accepted knowledge around ancient metalworking changed in the last few decades? I know that you have had quite a lot to do with this, Giovanna.

**Giovanna:** I did start showing up at conferences and saying that this is how things are done and coming at it from the point of view of a practitioner. One of the things is that everybody loves casting. Everybody loves fire. Everybody loves the transformative aspect of it going with molten metal pouring and becoming solid and everything else. But that's really like less than 10 percent of the work. That part's over in a flash. So I wrote my PhD thesis on every other aspect of metalworking. How do you make sheet metal? How do you rivet stuff? What tools do you need? What's the chaîne opératoire or the process of making these objects that you see? That's 90 percent of the work. Even if you have an axe that you cast, afterwards you have to possibly remove some flashing or you have to remove the pouring cup, you have to sharpen it by hammering it, there's all these processes that have just been ignored for so long and so I went about writing in detail about all those parts of metalworking. People just assume that you got some metal and you made something. Like there's some sort of miraculous thing happens and suddenly you have a gold cup with all these ridges that have been hammered into it without realising that, how do you hammer a cup from the inside?

**Phoebe:** Yeah, it's a really interesting point and it's funny what gets missed really.

**Fergus:** One of the things I've enjoyed looking at is different types of charcoal, charcoal made with different wood, because that was something else that when I started I just assumed all charcoal was the same, but it actually varies enormously depending on the species it's made from. So there's all these ancillary things around the metalworking. There's leather working and woodworking and charcoal making and all the rest of it and all these things have got to happen and the mining as well. You were saying with your question just now, what's changed in the last few years? There's also been lots of work done by people like the Early Mines Research Group. They've managed to identify about a dozen mines now, I think, dating back to the Bronze Age in mainland Britain. Because previously it was

always assumed that metalworking only really came in when the Romans invaded. But it's just nice to fill in a lot more of the prehistory to that. And I really enjoyed your PhD paper, Giovanna, looking at usewear and stuff like that on some of the tools. That was really fascinating stuff and I'm amazed no one had done that sort of work before, really.

**Giovanna:** I was pretty shocked too. When I started I was told I'd be lucky if I found maybe 20 hammers and bronze hammers in museum collections and by the time I was done, I had found over 100. People still contact me from the PAS or individual people who have been doing some metal detecting and tell me that they've found hammers. But touching on something that Fergus said there about the charcoal and the woodworking. In modern times we're just so divorced from craft work. The fact that we can go and just buy anything we want, we don't realise that crafts really don't live in a vacuum. They don't exist as an individual thing. A metalworker has to know how to work with clay and different types of clay and blend different types of clay. You have to know what kind of wood is good for making handles for axes, for hammers, for spears. There are just so many crafts that are intertwined and it's an issue about craft specialism. How much do different craftspeople collaborate on a project and how much is done by an individual who's just working in various different mediums?

**Fergus:** That's the thing that's always fascinated me, because now we tend to have specialists. We have people who cure hides, they do leather, they make charcoal, they're coppicers or something like that. But like you suggest, probably back then, the individual craftspeople would just have to dabble in all of these different crafts and have to have knowledge of all of them in order to work. And there does seem to be a lot of evidence for people being itinerant metal workers and travelling around in a lot of cases between communities maybe.

**Giovanna:** And even if a metal worker didn't actually mix the clay for a mould they would have to know enough about how to mix the clay in order to describe it to somebody else. Because when you make a mould, you have to make an inner layer that's very fine and porous. But then you need outer layers that are more robust and it can have more material included that will help the mould withstand thermal shock. But you do have to have these multiple layers built up, made out of different clay bodies. In Bronze Age moulds that you find broken, you can see the different layers that they were using.

**Fergus:** That's one of the things I'm not so keen on with modern life, because Britain's quite a crowded island and you're not really allowed to just go out into the countryside and dig up clay that you find, which is a great shame because that's the only way to find out the good stuff is just to try it out.

**Phoebe:** That's definitely a good point about how divorced we are from the natural world, in such a different way from how some of these people in the past must have been. It's a very different way of thinking about life.

**Giovanna:** Yeah, you also can't go off and go into a woodland and cut a branch that you need.

**Fergus:** I may be slightly luckier than you there because I know a few woods people who own parcels of woodland or manage them so I can generally go out and find what I'm after.

**Phoebe:** That's nice.



**Fergus:** It's tricky to find those things. We ought to talk about animal dung as well because that's how you spot ancient metalworking demonstrators and people because they always talk about animal dung and which is the best one to mix with clay for the moulds and things.

**Phoebe:** Oh yeah?

**Giovanna:** It's strange because I've got friends all over Europe and in our conversations we're connoisseurs of horse dung. We'll talk about are you somebody who likes working with it dry or wet? You just get into these very odd conversations.

**Fergus:** You certainly do and unfortunately we don't have horses at Butser so most of the time I'm forced to either use sheep or goat and it's not quite as good.

**Giovanna:** I've been looking into more and more chopped sheep's wool. In Britain especially, it always kind of bothered me that horses weren't really a thing in the Bronze Age there. What did people use for the organic material that would be in moulds? People have put me onto sheep's wool, especially the parts that are useless for weaving, the short, clumpy bits. Chop that up and mix that into the clay. So that's something I want to experiment with more.

**Fergus:** Yeah, it'd be good to try that. And if you were getting it off an old species like soays or something like that, which are very close to Bronze Age sheep, they tend to lose their wool naturally. It comes off on hedges and fences and stuff. So you can just pick out little bits. It's got a very short staple length.

**Giovanna:** And the white wool on the soays it's very coarse. It's almost like horsehair.

**Phoebe:** Do you think that would make a difference when putting it in a mould?

**Giovanna:** Well, when you make a mould the problem is that if you just used commercial clay bought at the store, made a mould, it would just crack, it would just break. You have to add what's called temper. It's different materials that allows the clay to expand and contract when it's subjected to extreme heat and cools. So it's materials used for mould making and making crucibles and making the furnace. You have to add some organic materials so that the clay can expand and contract without cracking.

**Phoebe:** And do you reckon a coarser sheep's wool would be better than a softer sheep's wool in that respect?

**Giovanna:** Probably, because a softer sheep's wool would tend to be hard to mix in. It would clump up too much, I think.

**Fergus:** A good thing to try.

**Giovanna:** But horse dung is the gold standard for mould making and crucible making.

**Phoebe:** Do you ever use animal dung as fuel or is it strictly in mould making that you use animal dung?

**Fergus:** I've not used it myself. I know Neil Burridge, the great bronze caster, he did some travelling in India and he saw them using dried cow pats there to melt bronze, taking longer than it would if you were using charcoal as a fuel, but the stuff is everywhere to use. So it would probably be quite successful and sheep dung dries really, really quickly.

**Giovanna:** There was an article in EXARC, I think two years ago maybe, where somebody did experiments with the thermal properties of, I think, donkey, sheep, and camel dung as a fuel source.

**Phoebe:** Speaking a little bit about fuels, I presume you need something like a furnace to melt metal. What kind of furnaces do you use? Are they permanent structures, semi-permanent? Do you just use them for one firing and then they're done? How did these vary in the archeological record? What can we actually see?

**Giovanna:** Well, first of all, anything of a furnace that was above ground is not there, from prehistory. All we've got is the footprint, or if it went into the ground at all. So anything about the height, the circumference at the top, if it narrowed, we don't know. It's all an experiment. But there are furnaces, they're like a shallow bowl and we have the dimensions of those and ones that look just like cooking hearths. But a lot of furnaces could have been built up. There's a great paper by [Bastian] Asmus on self-drafting furnaces. He excavated what he believed was the base of a self-drafting furnace and did experimental work and was able to get it hot enough to melt bronze and I've done this a couple times. With different people we've experimented with different sizes and different shapes and things. But that's an exceptional find.

**Fergus:** And they can be really very simple. I go out to quite a few country shows where I might be there for a day or two days for doing some copper smelting, just literally dig a shallow hole in the ground, just to hold about a bucket of charcoal and use that maybe once, maybe twice or three times. And then at the end just fill it back in. And it works. It just keeps extra air from getting into the furnace apart from what you're putting in via the bellows. It's very simple, but it works. It's just a small enclosure with some charcoal in. And even if you make it more substantial with a clay lining or something like that, unless you use it loads of times, you only get a very thin layer of vitrified clay on the inside. And I've got a simple little shallow bowl furnace at Butser I used twice 12 years ago and that has just vanished back into the landscape. I know exactly where it is, I can go there, I can find a few bits of charcoal, but the clay itself never really vitrified properly and plant roots and animals have just wrecked what was there. And that's after 12 years rather than 2000. These things do just vanish, unfortunately.

**Phoebe:** That's really interesting because you kind of think of metalworking as being quite a permanent thing in the archaeological record, I guess, because metal can be quite permanent itself. Like, you can find bits of metal that are pretty old, but very interesting to hear that the actual processes of making it can be so ephemeral.

**Giovanna:** I do have a couple of furnaces, bowl furnaces, just like that one in Germany that I've excavated, year after year and it's still there, but then we use it very intensively for about 10 days every year. And then the one here in northern Cyprus, at Vounos. The weather here is so dry that I have no problem with it ever disappearing.

**Fergus:** Picking up on that point and drier still, one of the very famous metalworking sites is Timna in what's now Israel. You've still got lots of furnace remains and everything there because it's just so dry. There's no weather really to destroy it. There's no large animals or vegetation. So these things can

survive if those factors are working in your favour.

**Phoebe:** Moving away slightly from talking about the actual techniques of metalworking. I know both of you do quite a lot of demonstrating and teaching. So I've got one or two questions about public engagement, one particularly about Butser Farm, and kind of does connect in with what we've been saying before. Do you think working in an ancient environment like Butser Farm can help you think more creatively or influence how you think about metalworking?

**Fergus:** I think it can, because there's just so many people there with so many different skills and it really helps with the crossover of ideas from one thing to another. It's not a metalworking example, but I've grown some of the ancient cereals, einkorn, emmer and spelt and when you actually see them growing in a field and you realise they're all different heights, not like modern crops that are very uniform height, you realise how difficult it would be to actually try and thatch with stuff like that. So being in an environment like that, where you've got lots of buildings and you've got lots of different skills being used by different people is just very fertile ground for getting inspired by other things around you. So yeah, it's a wonderful place to be.

**Phoebe:** You've spoken about how holistic metalworking can be in terms of you need so many different skills. Do you think having such a set of people who are skilled at such different things can be quite helpful?

**Fergus:** It certainly can be. I've been down there before and maybe I've broken the wooden nozzle on a bellows and someone has disappeared off into the woodland and come back with a suitable piece of wood and they've kind of bored it out and burnt it out and got me up and running again very quickly. So it's very handy having all these skills on hand. And it also acts as a magnet to bring in the public and they bring in skills and knowledge and information as well. Sometimes they see what we're doing and they get inspired. We had a couple of archeologists a few years ago and they were excavating an Iron Age site in Southampton, which is not too far away from Butser. And they had found this strange clay thing, a clay tube, and all they could theorise was that a wooden post had burnt down and baked the clay that was around the post in the hole. And it was actually a tuyere they'd found, this clay pipe that takes air from the bellows into a furnace. But they'd never seen one before, so they had no idea what it was. So they were just trying to figure out what it was, until they saw one in use at Butser and then they realised what they actually had.

**Phoebe:** My next question is a bit more broad. You touched on it a little bit, but why is it important to get the public engaged with ancient metalworking and what are the benefits and are there any drawbacks?

**Giovanna:** I think it's important for people to understand how things were done in a pre-industrial time, because it's hard for people to imagine that. That's why there's a certain amount of appeal for ancient aliens and humans couldn't do that because people are so far away from understanding how something was made. When I first bought a car, I could repair just about everything on it. It had a carburetor. If it didn't start in the winter in Minnesota, I would take a screwdriver and put it into the butterfly valve and warm up the motor and then take it out and I'm on my way. I could replace the starter motor. But nowadays, everything on a car is run by a computer. You can't just take it apart and put it together again. And even back in the 80s and 90s when I could do this sort of thing, you know kind of the end of the period when you could work on a car, there were very few people who actually did. You just took it in and had somebody repair it and if they couldn't repair it, you'd just buy a new one. We're getting so far away from how people made things. People know how cloth is made, but it's

very hard for people to imagine spinning and weaving enough cloth to make an entire sail for a ship. People were doing that and making everything for your own house. So when it comes to things like moving big stones or making things that are just beyond people's imaginations. Casting bronze, even something as simple as making a piece of jewellery or making an axe, people are suddenly aware that there's a technology out there that people are capable of doing and that everything we've got is just built on those original steps.

**Fergus:** I don't know if you've noticed this as well, but also the last few years, the children's computer game Minecraft has become more popular. I often find younger visitors to Butser now have at least got some grasp of the principles of smelting because they're doing it in Minecraft, albeit they're doing it in two minutes flat rather than 40. But it's quite interesting that they're picking up some of the language of the ancient past from playing a modern computer game.

**Phoebe:** It's actually so interesting that you mentioned Minecraft. I did an outreach session with my previous company and we had a little bit of obsidian. I was really expecting to blow all their minds with this obsidian, because it's such a cool material that you don't really get in Britain very often and they all knew what it was because of Minecraft!

**Giovanna:** It would be interesting to see kids who are into Minecraft to go to someplace like the Great Orme Mine where you can go into the mine and see the shafts people were working in.

**Phoebe:** I love that place, it's so cool!

**Fergus:** And you were saying, are there drawbacks to people getting involved with this stuff. I think there can be, because now you can go on YouTube. You can see thousands, possibly millions of videos of people doing bronze casting and all sorts of fun things, but you often don't see any warning about the dangers of them. Giovanna and I know that with things like carbon monoxide, with arsenic, even water, being really dangerous. If you pour molten bronze into a slightly damp mould, it's just going to explode and shower stuff everywhere. So the drawback to people getting involved with stuff like this is they don't always appreciate the risks and take the time and trouble to learn about them.

**Giovanna:** I have seen videos on YouTube that have just been like a poster for everything wrong to do.

**Fergus:** I had an example some years ago, some people had been trying to do some copper smelting and weren't getting anywhere and they wanted to pay me to go and spend the weekend with them, which I did, but I got them to send me a couple of sample bits of ore and I had it tested. It was azurite they'd bought off eBay and it was the highest arsenic levels I've ever seen in anything I've handled. So very, very glad they hadn't succeeded. I've got that in my collection now. I persuaded them it wasn't worth hanging on to.

**Phoebe:** That's a really important point to bring up, actually. Do you think that the public interest in metalworking has changed over the last few years?

**Giovanna:** I don't know. Are you talking about everybody or people who are particularly interested in archaeology or going to places like Butser Farm or reenactment events?

**Phoebe:** I guess both, really. Particularly for this episode people who are interested in it in an archeological response, but as Fergus mentioned, people are coming into contact with these slightly older technologies through things like YouTube and things. But I guess you wouldn't have been able to do that quite so much in decades previously before YouTube.

**Fergus:** I think before YouTube we were just stuck with reading these books written by academics who'd never done anything practical in their lives. As Giovanna said earlier, they left much to be desired.

**Giovanna:** Yeah, there was one person who had written about bronze hammers in Britain and classed them as big hammers and little hammers and never even looked at the face of the hammer and noticed that they were different shapes. Of course they're different shapes. A hammer that you use for riveting is going to be completely different than a hammer that you use for hammering out the sheet metal to make it flat or smooth or to forge. Nobody had thought to actually look at modern hammers or blacksmith shops and compare the ancient hammers to modern ones.

**Phoebe:** That's so funny, so detached. Well, that seems like quite a nice story to start wrapping things up on. Thank you so much for that really interesting discussion. It's been an absolute pleasure to listen in. So as a final question before we wrap up, what are your plans for the future and how can the EXARC community help to make a difference in regards to the points that we've discussed today? Would you like to go ahead first, Giovanna?

**Giovanna:** Well, I am here in northern Cyprus and I got here because Roeland Paardekooper of EXARC asked me if I would help out at an event. They needed somebody to cast metal. The event is the Vounous Symposium and I've been coming here every year ever since. The idea was that the Vounous Symposium gathers together people working in Bronze Age craft to recreate all of the sculptures and the objects that have been excavated here and taken away to museums around the world. So it's a way of restoring lost patrimony. The goal of the symposium wasn't just to do the crafts but to develop an open-air museum. Now this is finally getting the go-ahead, we've got government permission and it's pretty exciting because we're hoping to break ground sometime this year. The future is that there will be a new open-air museum that will present Bronze Age crafts, not just metalworking and ceramics, but cooking, textiles, glass making - we did glass making this year - and to have ongoing workshops for the public, symposia and masterclasses. All done in replicas of Bronze Age houses. So that's the future here. I'm enjoying it and it's really exciting.

**Phoebe:** That sounds absolutely amazing. I wish you all the best of luck and it would be amazing to come and visit in a few years once it's all set up.

**Giovanna:** I'll keep you all posted.

**Phoebe:** Fergus, what are your plans for the future and how can the EXARC community help to make a difference?

**Fergus:** When I am working down at Butser, because keeping the public entertained and informed and all the rest is the priority, I often get interrupted when I'm trying to do some research. So I'm going to build a couple of furnaces in my garden this year. I will build those over the winter so I've got somewhere that I can do research, without getting interrupted by passers-by. So that will be quite handy. And there's two particular things I want to work on next year. A few years ago, just for fun, I

made six batches, small batches of charcoal from different woods. And it's very interesting seeing how different they were one from the other. So I want to do that again and do it more scientifically this time to try and pin down what the differences are. And after years of trying, I finally managed to get some logs off a thing called the Wild Service Tree. That particular species of wood was used in the charcoal found at Maiden Castle, one of the big hill forts in southern Britain. So I want to find out what's special about Wild Service Tree charcoal, so that's on the agenda for next year. Also, although I've done lots of lost wax, it's been using beeswax to make wax models of things and then surrounding them with clay, melting the wax out and pouring metal into that clay enclosure. But I want to try something that's more widely available and would have been in the past, animal fat like beef and sheep fat, suet and tallow and stuff like that and see if they can be used for lost wax casting as well, which I think is going to be very messy and very smelly and probably a lot of fun.

**Phoebe:** Yeah, I was about to say that sounds like a lot of fun.

**Fergus:** I think so, yeah. In terms of EXARC, it would be really nice if we could get some kind of apprenticeship-type thing going, because I've learned so much in the 20 years I've been doing this. And it would be really nice to sort of share that knowledge more widely with someone who wanted to get into it, who was just perhaps starting out on a metalworking career or interest or whatever. So it'd be really nice if EXARC could offer some means of putting people together, people who've got knowledge, people who want to get the knowledge. So that would be a great thing for EXARC to do.

**Phoebe:** Yeah, that would be great, setting up some kind of network through EXARC. I'm sure there'll be lots of people who'd be very happy to be involved.

**Giovanna:** I thought of one other point to make. One of the things about working with metal, especially copper-based metals, is it's very polluting. Last year at the EAA and at the Historical Metallurgy Society conferences, I did a presentation about pollution and long term pollution and how we can use experimental archaeology to understand how what we're doing with smelting and casting affects the soil and the environment. This is starting to get some traction now. There's going to be an online conference in December, where people are discussing this more and I asked Fergus and I've been asking other people about at some point starting a project where we collect soil samples and see how does the soil change after x number of episodes of casting or smelting? Experimental archaeology in this case can give some idea about how long furnaces were in production or metalworking sites and really how much pollution does this cause? Is it minimal or is it something that spreads fairly far? It's something that we just haven't looked at in prehistoric contexts. We know for modern mining and processing, but not really on a small scale or even large scale for the Bronze Age.

**Phoebe:** That also sounds like a really amazing project. I'm sure you'll get some interesting results from that. So thank you very much Giovanna and Fergus for joining us today and sharing your experience and expertise. I know that I certainly learned a lot and I'm sure that our listeners did too.

**Fergus:** It's been a great pleasure.

**Giovanna:** Thank you for having us.

**Phoebe:** And thank you to everybody else for listening in to this episode of #FinallyFriday by EXARC. If you would like to become more involved with EXARC, why not become a member? Alternatively, you can make a small PayPal donation through the website to help support EXARC in its endeavors.

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