

Science Spotlight: Théobald GUFFON



About

My name is Théobald Guffon and I'm a French freelance geologist. I studied at the IPGS-EOST in Strasbourg and specialized in Alpine geology, petrography and fieldwork. I run my own company and work as a consulting geologist and 3D imaging professional (photogrammetry + 3D printing). You can have a look on my website for more information (in French):

<https://www.theobald-guffon.com/>

During my studies I took part in associations to improve the diffusion of geosciences. I think that it is very important to spread knowledge and give educational access to most people. To this end, I worked with museums to create scientific mediation workshops and started a YouTube channel to introduce geosciences in partnership with an educational association (in French):

<https://www.youtube.com/channel/UCHQVrTG7WF7JVuBQa-T0hw>

<http://ge-p-to.unistra.fr/>



I discovered photogrammetry during my master's degree thanks to a colleague, and it impressed me a lot! This technology has a huge potential in geosciences. For example, it's easier to study the 3D model of an outcrop than with only a few pictures.

For some time, I have been creating a virtual gallery of rock samples, minerals, and fossils and I plan on helping museums create virtual doubles of their collections. In my mind it is very important for scientists, teachers, and neophytes to have access to museum collections through internet in order to open scientific domains to everyone.

3D technologies can help shed light on geosciences collections thanks to scanning, modeling, printing and, more precisely, photogrammetry.

[\[https://sketchfab.com/tguffon/collections/photogrammetry-models\]](https://sketchfab.com/tguffon/collections/photogrammetry-models)

Geosciences & 3D

Geoscience is a wide scientific domain that contains geology, geophysics, geochemistry and a lot more! An important use of 3D technologies in such domains is that they improve our understanding and simplify our work. As an example, an aerial photogrammetry model of a mountain can help us to better understand how the sedimentary layers were folded when the mountain was raised.

[\[https://sketchfab.com/3d-models/stackpole-syncline-9e4466b58d844c2bab791009f0766706\]](https://sketchfab.com/3d-models/stackpole-syncline-9e4466b58d844c2bab791009f0766706)

In industry such technologies are already used to model quarries or oil reservoirs, but 3D has a lot more to offer! Academically, 3D allows you to instantly send models of specimens and outcrops to scientists on the other end of the world, or to create a record of geological features before a destructive analysis. Moreover, 3D technology can also be used for spatial mapping and reconstruction.

For educational purposes, 3D models and 3D prints are a playful, modern and cheap way to show children scientific or rare materials. This is a way to give more visibility to our cultural heritage and to scientific museums on the principle of open science.

[\[https://sketchfab.com/3d-models/impact-breccia-rock-1-46mo-015xv-100xir-be87727f69384918bf704b08d45d6233\]](https://sketchfab.com/3d-models/impact-breccia-rock-1-46mo-015xv-100xir-be87727f69384918bf704b08d45d6233)

In my opinion, 3D technologies will develop a lot in the scientific domains in the coming years because they allow us to save, copy, and distribute physical elements.

To create my models, I use a technique called photogrammetry. To make a very quick summary, the principle of photogrammetry is to take a lot of pictures of an object, then merge them to recreate this object in three dimensions on a computer. These objects can be of all scales, from small like a seashell to gigantic like a mountain.

The first models I put on Sketchfab when I discovered it are the models of fossils from the Messel deposit I saw at an exhibition in France. These fossils are very interesting because they are incredibly well preserved! If you zoom in on the model of this crocodile, you will be able to see the details of its skin. I was stunned by the conservation of this 50 million years old fossil, and I wanted to capture a 3D model of it so everyone can admire it. To me, a 3D model is more instructive than a picture concerning natural sciences objects.

<https://sketchfab.com/3d-models/crocodile-fossil-1-39mo-010xv-050xir-7927b78b77c7446681e13c51650c4191>

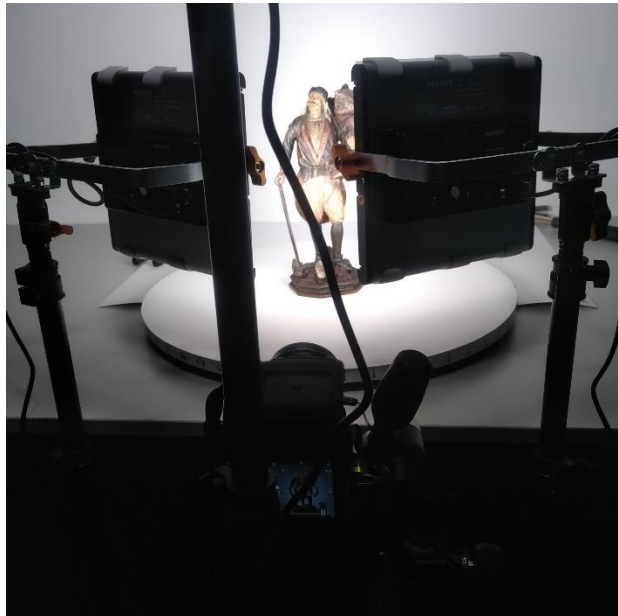
<https://sketchfab.com/tguffon/collections/fossils-from-messel>

Photogrammetry hardware

I will give you a glance of the hardware I use for photogrammetry.

I have a (very) good computer, with a new generation CPU (i7) and a 1070 Nvidia (because of CUDA) GPU, with a lot of RAM (16Go) and a good cooling because photogrammetry softwares are highly demanding.

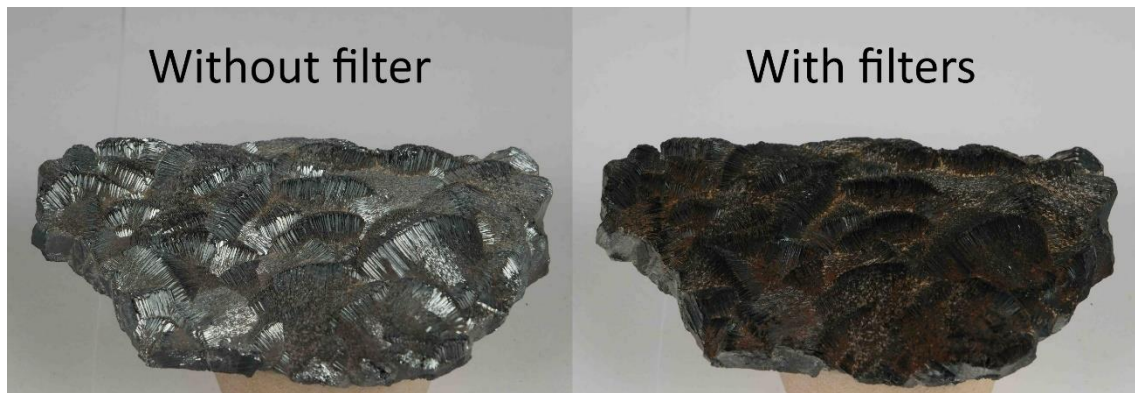
Even if a cheap smartphone can do it, I recommend you use a good camera and a good lens. I use a zoom lens (like 24-105mm) because you can more easily adapt your view (if your software is comfortable with it), but for small objects I use a macro lens (like 60mm or 100mm). The type of the camera is not so important, but it must generate complete EXIF files and better shoot in RAW.



Caption: An example of my setup, lighting is very important!

If, like me, you mostly work on objects, I recommend you use a big and heavy tripod, so your camera won't move at all (mine is a Manfrotto, expensive but well-built). You will also need 2 or 3 strong LED lights at 5500K for natural color (I use 3 dimmable LED panels) and a turntable with a background (I use thick white paper sheets). Personally, I built my own manual turntable, but you can find expensive controlled turntables or very cheap lazy susan.

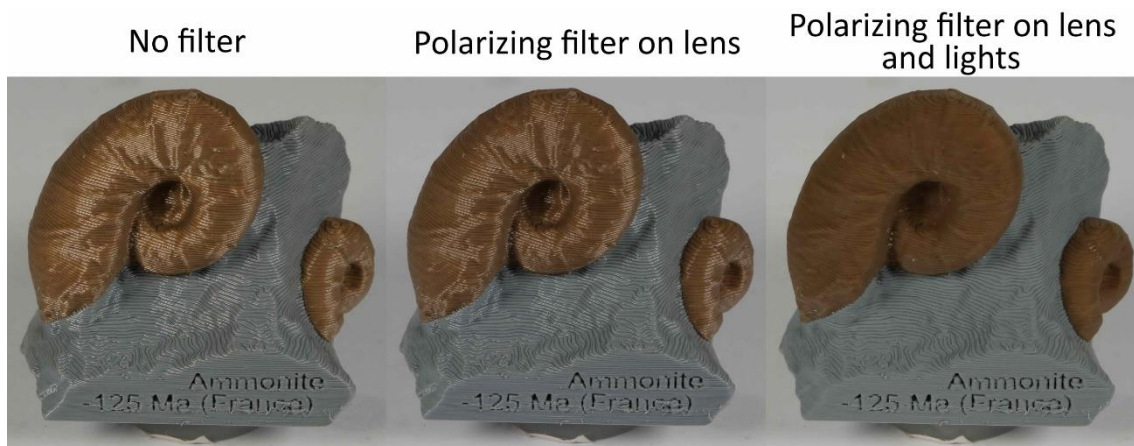
An important tip I discovered by experimenting, is that I get better results with a circular polarizing filter on my lens and linear polarizing filters on my lights, because it allows me to avoid all reflections on the object. This is a real challenge concerning minerals because most of them have highly reflective surfaces. In this case I can't use something to cover the object to avoid reflections. Thanks to the polarizing filters this tricky problem due to the glassy or the metallic radiance is easily overcome.



Caption: Comparison of the impact of the polarizing filters on a very shiny hematite.

[\[https://sketchfab.com/3d-models/hematite-1-44mo-03xv-100xir-dd8496188e8a4d478fd3a621983e167d\]](https://sketchfab.com/3d-models/hematite-1-44mo-03xv-100xir-dd8496188e8a4d478fd3a621983e167d)

As a picture is better than thousands of words, you can see below the effect of polarizing filters on a 3d printed reproduction of a fossil:



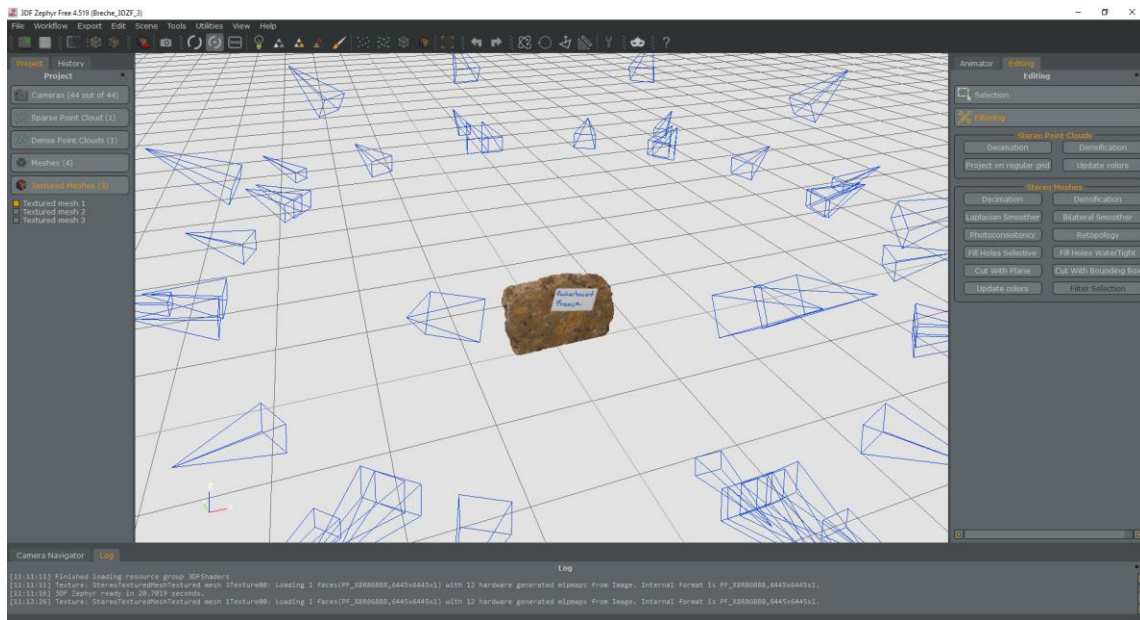
Caption: The combination of lens and lights polarizing filters remove almost all reflections.

To sum up, if you want to start to use photogrammetry, you need a good computer and a camera, but all the other things are optional and depending on what you want to model.

Photogrammetry software

Personally, I use Meshroom (which is completely free), 3DF Zephyr Lite (which has a nice free version) and Reality Capture (which is paying for export or subscription), but it depends on your budget and use.

To stay simple, once you gave it your pictures (JPEG or better RAW), your software will try to position your camera for each picture. Usually I shoot between 200 and 600 pictures to scan an object, but if you optimize your camerawork, 50 pictures might suffice. Then it will create a point cloud from which it will construct a mesh and a texture.



Caption: An example of my virtual setup on 3DF Zephyr Free.

There are a lot of softwares available, and you easily can find comparison tests on the web depending on your goal.

There are free useful softwares I often use like De-Lighter to remove shadows on textures, Instant Meshes to improve the mesh, Blender to repair the model, GIMP to repair the texture and the very useful Windows 3D Viewer because it's a fast way to see your models.

It is necessary to decrease the size of your model if you want to share it because there are size limitations on host websites (e.g. 50Mo for Sketchfab free). The easiest way is to use the decimation tool of your software (have a look on what retopology is). Generally, I reduce it to about 350 000 triangles for Sketchfab. For the export, .obj is always a good choice, .glb is interesting for web use and .stl for 3D printing.

3D printing

I have used FDM 3D printing for some time, and I am convinced that these machines are amazing and will have an enormous impact on the way we consume and learn.

Even if this seems obvious, I had not made the link between photogrammetry and 3D printing until recently. I didn't realized that these two methods were so powerful. Most models on Sketchfab are not intended for 3D printing, but by working on them a bit you can obtain wonderful and original printed objects.

As an example, I printed some of my photogrammetry models and some other models I found on the site. They all look amazing and to me being able to copy specimens will have a huge impact on how we teach natural sciences; the process allows students to practice on cheap printed models.

<https://sketchfab.com/3d-models/ammonite-fossil-1-45mo-040xv-100xir-40264f0e1ba04d388f1829149217c6b6>



Caption: The dual-color 3D print of the model of this ammonite.

[\[https://sketchfab.com/3d-models/cephalopod-perisphinctes-sp-a57e4e04cbf845d89e3d7d331e5d3cce\]](https://sketchfab.com/3d-models/cephalopod-perisphinctes-sp-a57e4e04cbf845d89e3d7d331e5d3cce)



Caption: The 3D print of the model of this other ammonite.

Even if you can directly slice your photogrammetry model in a software like Cura (which is free) and hope the outcome will be good, I recommend you modify the model first. There are a lot of free softwares that I use for that: Meshmixer to clean and repair the mesh, Blender to sculpt the model, and Fusion360 to add a stand to the model, for example.

Necessarily, you need a 3D printer to print photogrammetry models. But if you don't have one, you can rent one in a FabLab or make an order to a 3D printing company. If you are not familiar with 3D printing, you should first try with a mono-extruder printer, because a dual-extruder (or more!) printer is much more difficult to use. I use the two types and dual-color prints will allow you to achieve more complex and nicer models.

Prospect

As a geologist, I'm interested in expanding the range of my photogrammetry by trying aerial and micro photogrammetry.

With a drone, doing photogrammetry on an outcrop will be easier, and a drone should allow me to make a photogrammetric model of a whole mountain. Visualizing and printing this model to have a virtual and a hand-sized version of the real-life feature should help researchers to understand such areas and make reconstructions.

Micro-photogrammetry uses a microscope (even an SEM!) to take pictures of very small samples, such as minerals, and uses them to reconstruct a 3D model. I already saw nice results of this workflow and I'm very excited to try it someday!

[\[https://sketchfab.com/3d-models/microscopia-fire-ant-cc170deb00fe4a748d1e7ca705d75fbf\]](https://sketchfab.com/3d-models/microscopia-fire-ant-cc170deb00fe4a748d1e7ca705d75fbf)

In an ideal world, I would like to improve my work by using laser scanners for modeling combined with photogrammetry for texturing and by constructing an automated motion turntable synchronized with 4 cameras to increase the speed of the process.

I am currently looking for contacts in natural sciences museums, and, more precisely, geosciences museums, to develop partnerships and to diversify my activity.

Conclusion

I have some pro-tips to give you if you want to start doing photogrammetry combined with 3D printing:

- Be patient, very patient, because you will learn a lot from trial and error.
- Start small with objects that are optimal for photogrammetry.
- Vary your tests, try different things to understand which way works the best.
- Take notes, a lot of notes, it will help you identify the problems you encounter and find a solution.

If I have the opportunity, I would love to try photogrammetry on a dinosaur, or even a paleontological excavation site! I also would like to push photogrammetry to the limit and try it in difficult in-situ conditions, like a mine.

I think that my favorite model on Sketchfab is the model of the Tyrannosaurus Rex and Triceratops fight made by the Smithsonian DPO on Thomas Flynn's page.

[\[https://sketchfab.com/3d-models/tyrannosaurus-rex-triceratops-smithsoniandpo-e9fa58a7f25645db99b9519073c88b40\]](https://sketchfab.com/3d-models/tyrannosaurus-rex-triceratops-smithsoniandpo-e9fa58a7f25645db99b9519073c88b40)

My favorite user is Digital Atlas of Ancient Life from PRI because people working on this project are doing an amazing job with fossils!

[\[https://sketchfab.com/DigitalAtlasOfAncientLife\]](https://sketchfab.com/DigitalAtlasOfAncientLife)

[\[https://sketchfab.com/blogs/community/science-spotlight-digital-atlas-of-ancient-life/\]](https://sketchfab.com/blogs/community/science-spotlight-digital-atlas-of-ancient-life/)

If you are interested in photogrammetry and 3D printing, more especially concerning geosciences, feel free to contact me to ask questions, discuss my workflow or to hire my services.

Biography

I'm a freelance geologist from France, working a lot with photogrammetry and 3D printing. I am involved in scientific and cultural heritage dissemination projects.

My website: [<https://www.theobald-guffon.com/>]

