Freehand stereo-photography – examples from a visit in Washington, D.C., USA

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Stereo-photography is a very simple method to provide a spatial impression of a three-dimensional object in a two-dimensional image. The following text is thought to provide a short introduction and examples into freehand stereo-photography.

We have already presented examples in which we used light-field photography to calculate virtual surfaces of a scene and do virtual stereo images of those (see here). In our scientific worklife we often do stereo images by mounting the camera on a special repro-stand (examples: 1 and 2). Yet, such a set-up demands that the object is small enough to fit under the set-up, and you need to have direct access to the object.

As with our report about light-field photography and our work on "photographing fossils behind glass" we are also interested in documenting objects in public exhibitions and alike. Therefore, we will present examples of stereo photos of objects taken in such public exhibitions (or similar locations) that we documented during a research visit in Washington, D.C., in 2012. We worked in the collections of the Natural History Museum of the Smithsonian Institution, but took a public holiday to also do some sightseeing. The equipment was nothing more than our Ricoh R8 compact camera. The built-in flash and the lens are equipped with perpendicular polarization filters (attached with small pieces of scotch tape) to reduce reflections. All images were shot "from the hand", i.e., no tripod or similar tools were used.

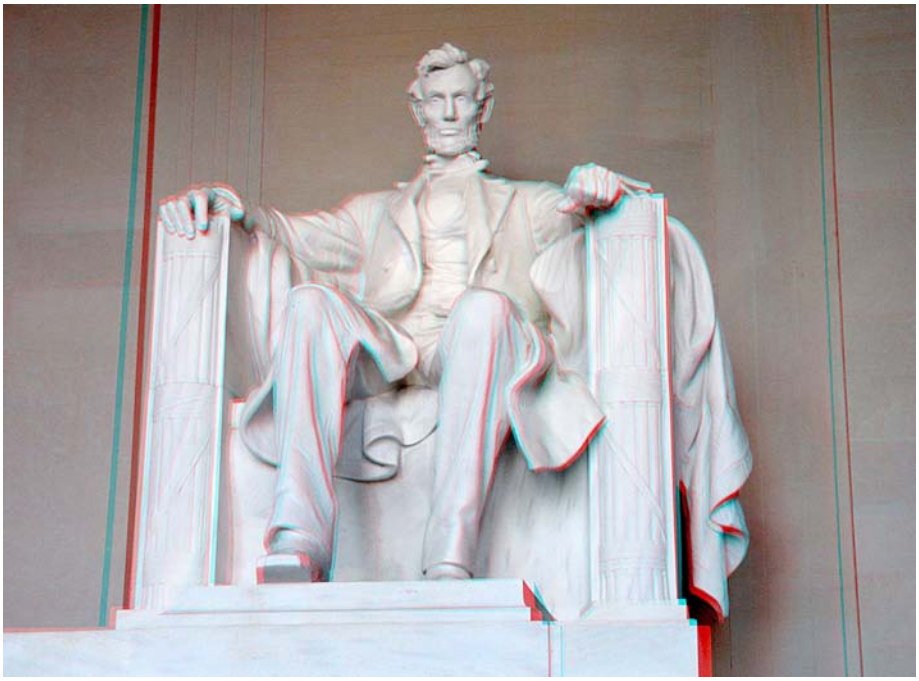


Figure 1. Lincoln Memorial. The impressive statue of the late President Abraham Lincoln was something that we wanted to have documented. This image was taken without a flash. One has to stay quite at a distance and move also quite a bit sideways. The images could be used in their natural "color" as there is not too much color in them that could cause interference with the color of the anaglyph. **Please use red-cyan-glasses to view**

For shooting a stereo image one needs to photograph the same scene from (at least) two different angles. For doing so you should not change the height of the camera, but make a step to the side while still aiming at the object. Many custom stereo set-ups move the camera straight along a short rail. Yet, to our experience the effect is better if you instead rotate along a circle with the desired object in the center. The exact distance is difficult to calculate. It heavily depends on the size and especially depth of an object, as well as your distance to the object. It is therefore a good advice to take not only one pair of images but several ones which differ in small steps. Later on it is then possible to evaluate whether two images are not "far enough" rotated. If so, you do simple not use images 1 and 2, but 1 and 3, or even further apart ones.

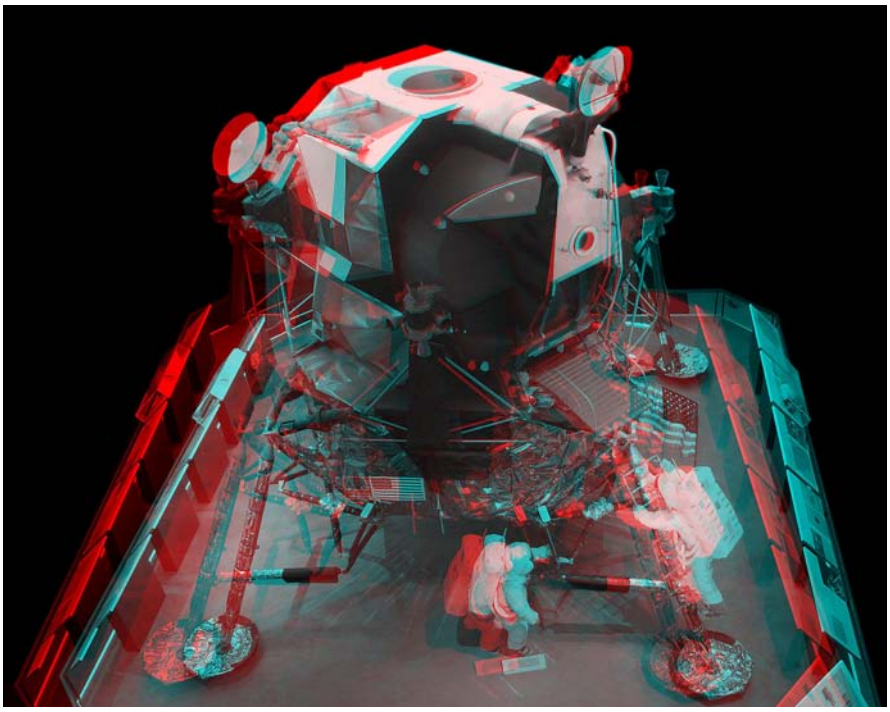


Figure 2. Not the eagle, but it is its original back-up. It was photographed from a balcony downwards. The Apollo lunar module stands right next (in fact left) to the entrance of the McDonald's (as stated before, going to museums with a family with small children is easier if you can eat somewhere where they have simple food). The images benefitted from the handrail of the balcony. The background was removed manually, to get rid of the moving people. **Please use red-cyan-glasses to view**

After taking the images you will still need to present them in a way that you can indeed enjoy the depth impression. A classical method is presenting them as stereo pairs. But for viewing these pairs you need to know how to correctly stare at them. Therefore, this is in fact not something for a broad audience (on the other hand, if you are able to stare in this way, it will help for the next few steps). As such stereo pairs are (comparably) difficult to view we mostly prepare our stereo images as red-cyan stereo anaglyph images. These provide a depth impression when they are viewed with red-cyan glasses, which are indeed the most widespread type of such bi-colored glasses; many households appear to have glasses like those (otherwise they are cheaply available, less than a dollar in different shops).

There are commercial programs that automatically transform a pair of stereo images into a red-cyan stereo anaglyph, yet the possibilities of such programs are limited. We suggest to use GIMP or, if you have access, Adobe Photoshop (we are in particular happy with CS3, some features are lacking in later versions); you will have more options in such programs!

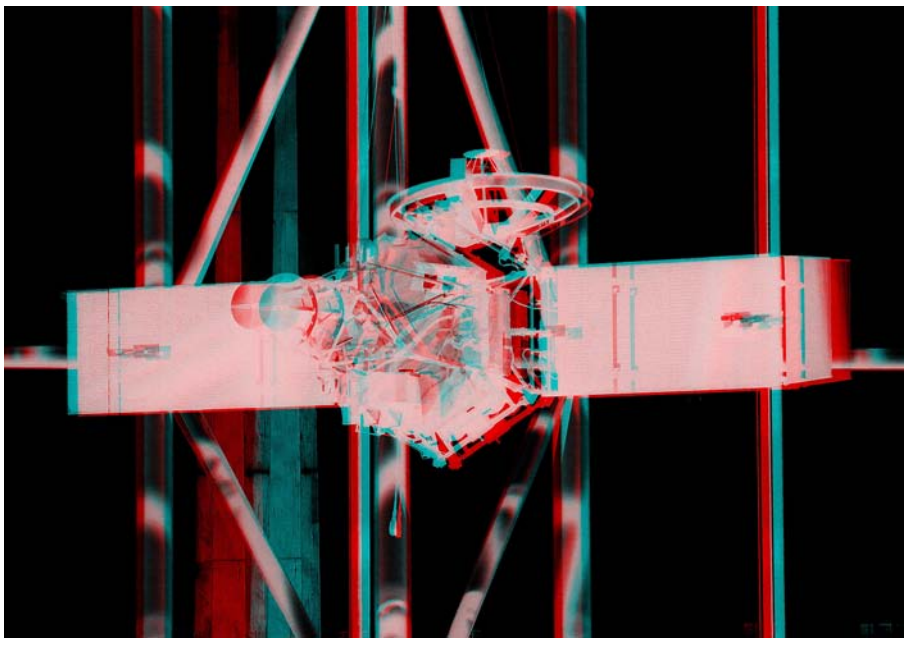


Figure 3. Replica of the Mariner 2 Venus probe. As with the Apollo lunar module, the images were shot while the camera was stabilized by a handrail. The images were desaturated, because some colors were disturbing. The background sky was eliminated by first desaturating the blue into a bright white. The image was then inverted to emphasize the probe (which otherwise would be very dark). **Please use red-cyan-glasses to view**

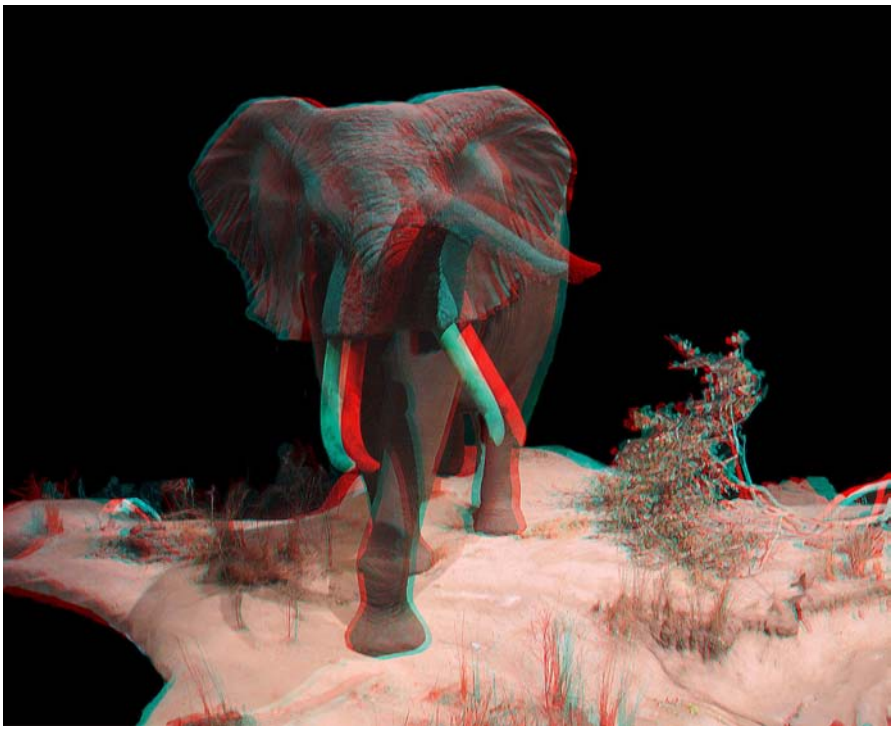


Figure 4. The elephant in Natural History Museum of the Smithsonian Institution. It stands in the entrance hall towards the park. Front view. The images were shot from one floor above. Again, we made use of the handrail to stabilize the camera. In the background, a lot of people were moving (it is the entrance hall); therefore, the background had to be "cleaned". The colors are not very strong, so they could be left in, without causing any flickering or other artifacts. **Please use red-cyan-glasses to view**

If you are able to get a depth impression by staring at stereo pairs, you have an advantage. Somehow you have to decide which image should be seen by the right eye and which one by the left eye. If you cannot stare, you will have to try: prepare the stereo image and check whether it is correctly assembled.

Yet, it is in fact not so easy for many people to see whether a stereo image is "the right way around" or if it is depth inverted (see 1 for the advantages of depth inversions in certain cases). So take your time to inspect your stereo images after you have done the following procedure:
1) The right image is put as a separate layer above the left image (if you cannot differentiate these, you will have to try which is the right way).
2) Make the upper layer 46% transparent (experience by Prof. Dr. Dieter Waloszek, Ulm).

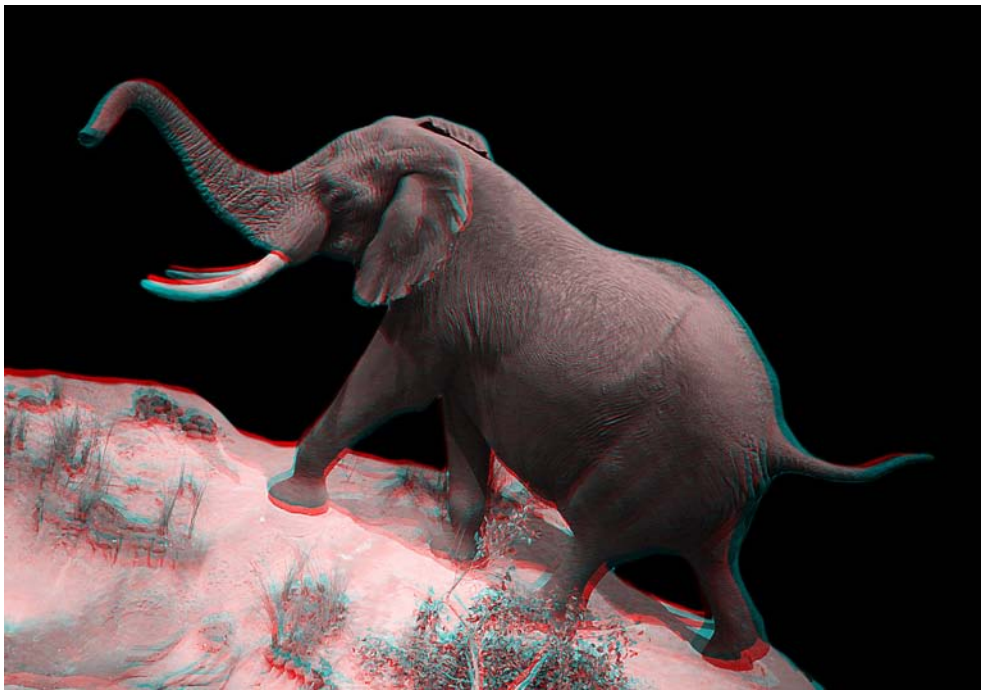


Figure 5. The elephant, now in side view. We simply walked around on the balcony of the floor above to change the angle of view. Interestingly there was a rather red area on the ground in this view. Therefore the stereo pairs were desaturated before assembling the anaglyph.

Please use red-cyan-glasses to view

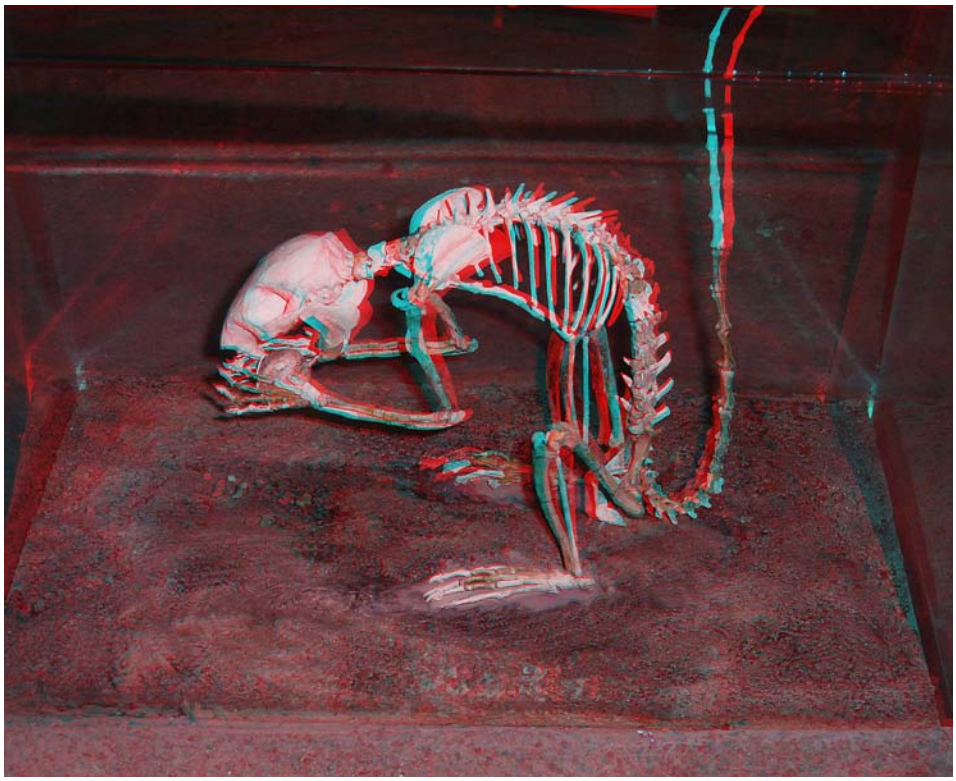


Figure 6. A fossil squirrel (no joke!). *Protosciurus* sp. Late Eocene (37-32 million years). This one was a bit tricky because of the glass, but luckily here our polarization filters reduce reflections tremendously.

Please use red-cyan-glasses to view

3) Open the histogram (image => adjustments => levels) of the upper layer, choose 'red-channel' and move the 'output level' (or equivalent) to '0'.
4) Open the histogram of the lower layer, choose 'blue-channel' and move the 'output level' to '0', repeat the same for the 'green channel'.
5) Merge both layers.
6) Open the histogram, it will be way too dark; move the right mark of the input level to the left until you 'hit' the right side of the histogram.

For step 1 you can play a bit how to exactly place the images onto each other. As the two layers show the same scene, but from two slightly different angles, the images will not exactly match. So the question is: which structures do you choose to match? Usually it is best to match those structures that are the most interesting ones. In the case of the lunar landing module (Fig. 2) the module itself is (more or less) matched, but not, for example, the surrounding handrails. It is a bit more difficult in very deep objects; in the case of the elephant seen from the front (Fig. 4) we did not choose the trunk but the body. If we would have chosen the trunk, it would have been difficult to see the far back end of the elephant correctly. That is, in fact, a typical artifact of many stereo anaglyphs that certain areas cannot be really matched, because they are too far apart. In such cases the depth impression is not correctly reconstructed and you will end up with having perception artifacts. Therefore, take some time, play around with the matching.

Another aspect to play around is the color. It is possible to keep the images in their original color (e.g., Fig. 1). Yet if there is structure in bright red or green-blue, there is a strange effect. You will be able to see the color on one eye but not on the other. This will cause a kind of flickering and disturbs the depth impression drastically. In such a case it is better to desaturate the pair of images before assembling them to a stereo anaglyph (e.g., Fig. 3). You can also desaturate in steps to emphasize certain structures and suppress others,

for example, the background. For doing so you open the saturation menu and choose a single color, the one you want to have reduced in reception. Then you change the lightness of the color either to complete white or black, depending on the brightness of the remaining scene. Afterwards, the entire image is desaturated.

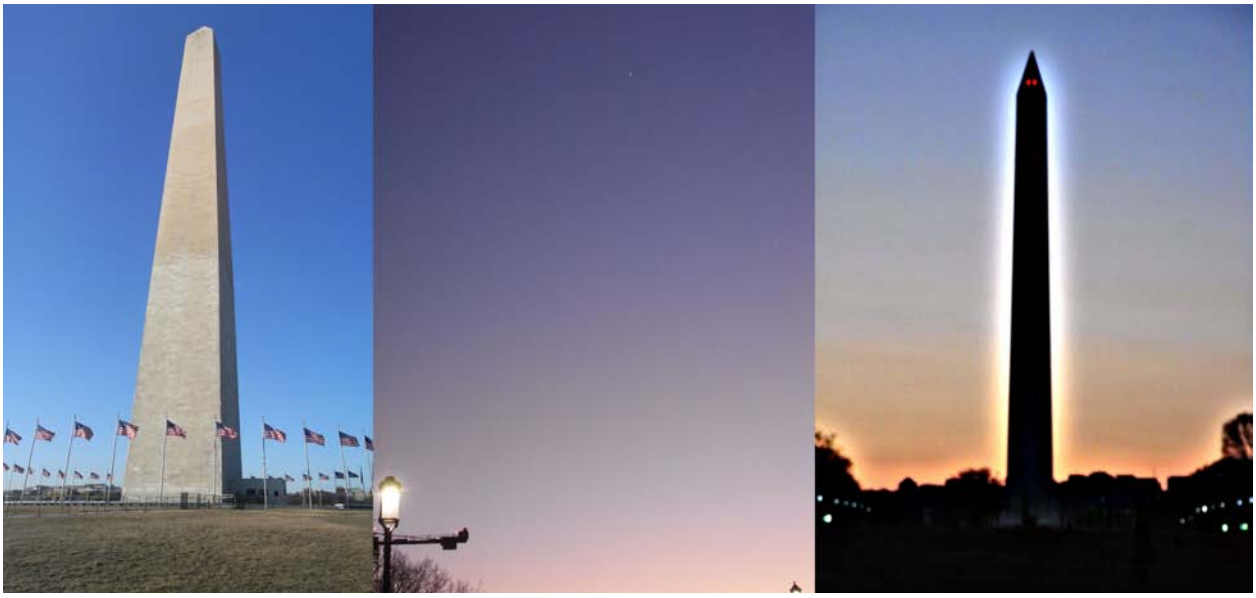
In some cases it can also be helpful to invert the image. If the structure of interest is very dark and the other areas of the images are very bright, the structure of interest almost “disappears”. Inverting the image will have the opposite effect, the then very bright structure will be emphasized.

A last aspect is a very time consuming, but sometimes necessary manipulation of the images: erasing the background by hand. In many of the images presented here many people were moving around in the background. As it takes some time to take the second image of the pair (and the third...) people next to the object have moved on. Thus, they will not match in the stereo anaglyph. Furthermore, for presenting images of objects in public exhibitions in the internet it is better not to have images showing people which might not want to be shown on such photographs. Also in cases in which the flash was used, the cast shadows can be tricky to match. Therefore, removing the background, and thus the cast shadows, increases the depth effect.

The challenging aspect of removing the background is to do it in the same way in both half images. Everybody will have his preference how to remove the background. Some people use the brush or the eraser. We usually use a combination of the magic wand and lasso tool, give the edge a certain degree of feather and cut it. We then add another layer, usually completely filled black, and merge these two layer. As stated this procedure is very time-consuming, but worth it. Compare further below the stereo images of early humans.

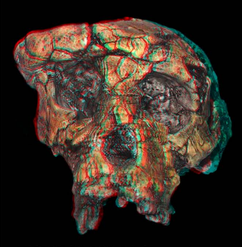
We encourage everybody to play a bit with the here described procedure. We are happy to receive comments about results or answer further questions.

We thank the Smithsonian Institution and also hope that the here presented images act as an advertisement for these beautiful museums.



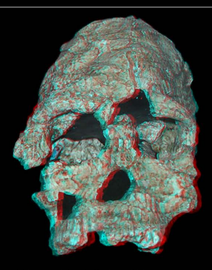
Some additional impressions from our visit, but not as stereos. Left: Washington Monument, stitched from several images. Middle: Venus over Washington, D.C. Right: Washington Monument at sunset treated with some filters.

Sahelanthropus tchadensis



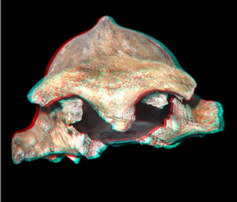
TM266-01-060-01, Toumai; Toros-Menalla, Chad; ca. 7–6 Ma

Kenyanthropus platyops

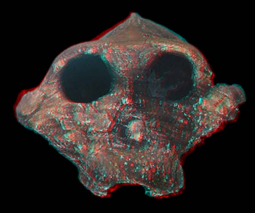


KNM-WT 40000; West Turkana, Kenya; ca. 3.5 Ma

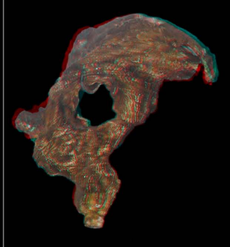
Paranthropus boisei



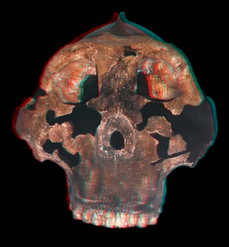
KNM-ER 23000; Koobi Fora, Kenya; ca. 1.7 Ma



KNM-ER 406; Koobi Fora, Kenya; ca. 1.7 Ma

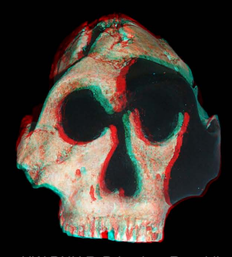


KNM-ER 732A; Koobi Fora, Kenya; ca. 1.7 Ma

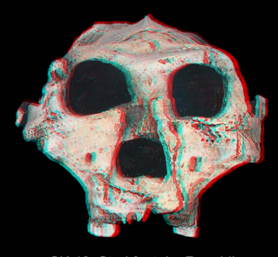


OH 5, Nutcracker Man, Zinj; Olduvai Gorge, Tanzania; ca. 1.8 Ma

Paranthropus robustus

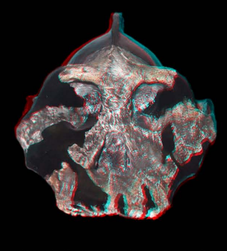


UW DNH 7; Drimolen, Republic of South Africa; 2.0–1.5 Ma

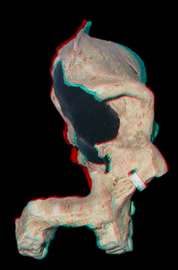


SK 48; Sterkfontein, Republic of South Africa; 1.8–1.5 Ma

Paranthropus aethiopicus

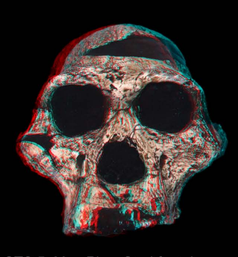


KNM-WT 17000, The Black Skull; West Turkana, Kenya; 2.5 Ma

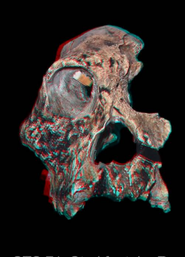


SK 46; Swartkrans, Republic of South Africa; 1.8–1.5 Ma

Australopithecus africanus

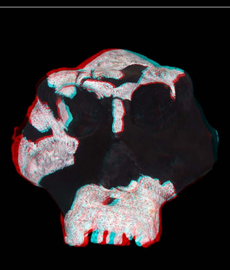


STS 5, Mrs. Ples; Sterkfontein, Republic of South Africa; 2.5–2.1 Ma



STS 71; Sterkfontein, Republic of South Africa; 2.8–2.4 Ma

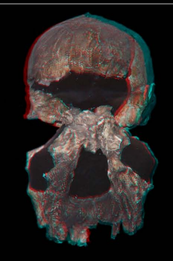
Australopithecus afarensis



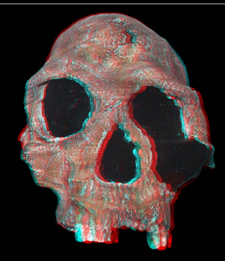
AL444-2; Hadar, Ethiopia, ca. 3 Ma

STW 13; Sterkfontein, Republic of South Afrika; 2.8–2.4 Ma

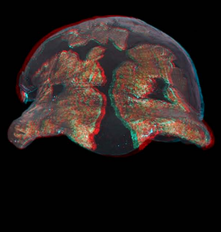
Homo habilis



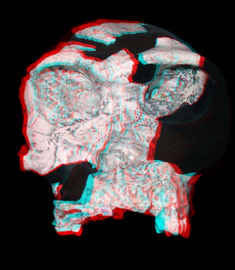
KNM-ER 1805; Koobi Fora, Kenya; ca. 1.74 Ma



KNM-ER 1813; Koobi Fora, Kenya; ca. 1.9 Ma

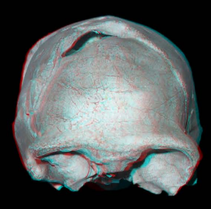


OH 16; Olduvai Gorge, Tanzania; ca. 1.7 Ma

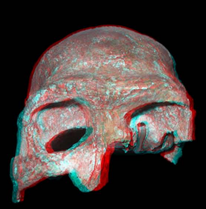


OH 16, Twiggy; Olduvai Gorge, Tanzania; ca. 1.8 Ma

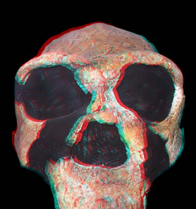
Homo erectus



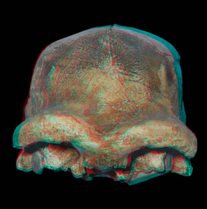
KNM-ER 42700; Koobi Fora, Kenya; 1.6–1.5 Ma



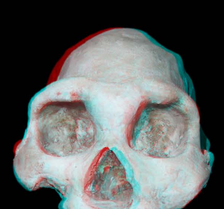
KNM-ER 3883; Koobi Fora, Kenya; ca. 1.6 Ma



KNM-ER 3733; Koobi Fora, Kenya; ca. 1.8 Ma

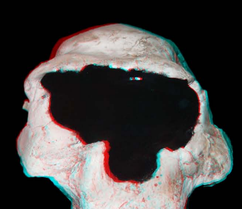


Daka BOU-VP-2/66; Middle Awash, Ethopia; ca. 1 Ma



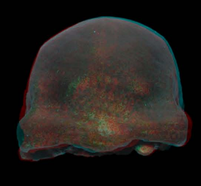
D3444; Dmanisi, Republic of Georgia; ca. 1.77 Ma

D2700; Dmanisi, Republic of Georgia; ca. 1.77 Ma

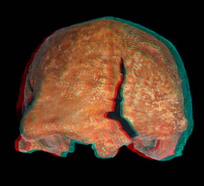


D2282; Dmanisi, Republic of Georgia; ca. 1.77 Ma

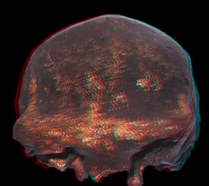
Sangiran 2, Pithecanthropus II; Sangiran, Java, Indonesia; >1 Ma



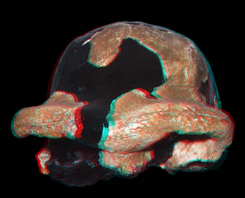
Ngandong 14; Solo River, Java, Indonesia; 250,000–70,000 a



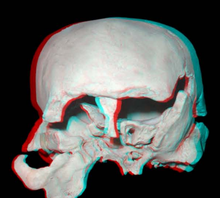
Ngandong 13; Solo River, Java, Indonesia; 250,000–70,000 a



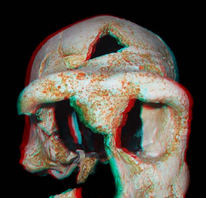
Ngandong 7; Solo River, Java, Indonesia; 250,000–70,000 a



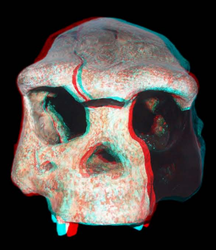
OH 9; Olduvai Gorge, Java, Tanzania; ca. 1.4 Ma



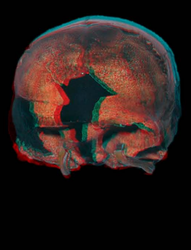
Salé; Salé, Morocco; 250,000–200,000 a



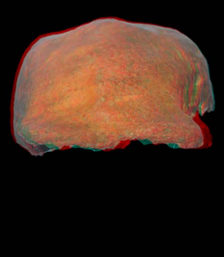
UA 31; Buia, Eritrea; ca. 1 Ma



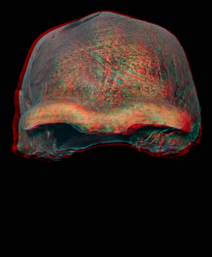
Sangiran 17; Sangiran, Java, Indonesia; 1.3–1 Ma



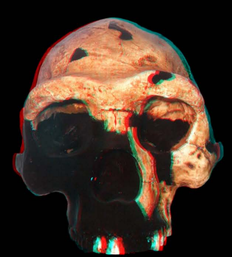
Mojokerto; Mojokerto, Java, Indonesia; 1.8–1.6 Ma



Trinil 2, Java Man; Trinil, Indonesia; 1 Ma–700,000 a

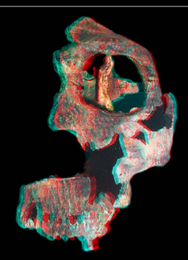


Zhoukoudian III, Locus L; Zhoukoudian, China; 780,000–400,000 a



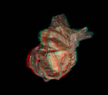
Zhoukoudian III, Peking Man; Zhoukoudian, China; 780,000–400,000 a

Homo habilis or *erectus*



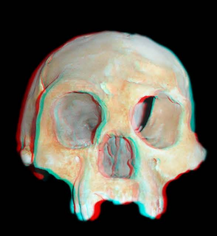
SK 847; Swartkrans, Republic of South Africa; 1.8–1.5 Ma

Homo habilis or *rudolfensis*



KNM-BC1; Chemeron, Kenya; ca. 2.4 Ma

Homo florensiensis



LB1, Hobbit; Liang Bua Cave, Flores, Indonesia; 18,000 a

Homo rudolfensis

KNM-ER 1470; Koobi Fora, Kenya; ca. 1.9 Ma

Homo heidelbergensis

Kabwe 1, Rhodesian Man; Kabwe, Zambia; ca. 300,000–125,000 a

Bodo; Middle Awash, Ethopia; ca. 600,000 a

Arago 21; Tautavel, France; 450,000 a

Saldanha; Elandsfontein, Republic of South Africa; ca. 500,000–200,000 a

Petralona; Petralona, Greece; ca. 350,000–150,000 a

Ndutu; Lake Ndutu, Tanzania; ca. 350,000 a

Maba; Guangdong Province, China; ca. 130,000 a

Steinheim; Steinheim, Germany; ca. 350,000–250,000 a

Homo neanderthalensis

Feldhofer, Neanderthal Man; Feldhofer Cave, Neander Valley, Germany; ca. 40,000 a

Krapina 3; Krapina, Croatia; ca. 130,000 a

Engis 2, child 4–5 a; Awirs Cave, Engis, Belgium; age uncertain

Teshik-Tash, child 8–11a; Bajsuntau, Uzbekistan; ca. 70,000 a

H. heidelbergensis or *helmei*

Florisbad; Florisbad, Republic of South Africa; 259,000 a

La Chapelle-aux-Saints; La Chapelle-aux-Saints, France; ca. 60,000 a

Subalyuk 2, child ca. 3a; Subalyuk Cave, Hungary; ca. 110,000–80,000 a

Pech de l'Azé I, child, 2–3 a; Pech de l'Azé, France; 90,000–65,000 a

La Quina H18, child, 7–8 a; La Quina Rock Shelter, France; 65,000 a

Saccopastore 1; Rome, Italy; 130,000–100,000 a

Saint-Césaire; Saint-Césaire, France; ca. 36,000 a

La Ferrassie 1; La Ferassie Rock Shelter, France; ca. 70,000–50,000 a

La Quina H5 1; La Quina Rock Shelter, France; ca. 65,000 a

Gibraltar 1; Forbes' Quarry, Gibraltar; ca. 70,000–40,000 a

Zuttiyeh; Wadi Amud, Israel; ca. 300,000–200,000 a

Tabun 1; Mount Carmel, Israel; ca. 122,000–50,000 a

Amud; Wadi Amud, Israel; ca. 41,500 a

Homo sapiens

Cro-Magnon 1; Cro-Magnon France; ca. 30,000 a

Hofmeyr; Hofmeyr South Africa; ca. 39,000–33,000 a

Kow Swamp 1; Kow Swamp, Australia; ca. 13,000–9,000 a

H. sapiens or *heidelbergensis*

ES 11693; West Turkana, Kenya; 300,000–200,000 a

H. heidelbergensis or *cepranensis*

Ceprano; Ceprano, Itally; 1 Ma–700,000 a

Ngaloba LH 18; Laetoli, Tanzania; ca. 120,000 a

Singa; Singa, Sudan; ca. 150,000–130,000 a

Qafzeh 6; Jebel Qafzeh, Israel; ca. 100,000 a

Qafzeh 9; Jebel Qafzeh, Israel; ca. 100,000 a

Skhūl V; Mount Carmel, Israel; ca. 120,000–80.000 a

PLEASE NOTE that all images shown here are red-cyan stereo anaglyphs. For achieving a 3D-impression, please use red-cyan glasses to view, red filter on left eye, cyan filter on right eye.

All objects shown here are on display in the Human Origins exhibition of the Smithsonian National Museum of Natural History, Washington, D.C., USA (date of record, February 2012). In general, specimens represent casts or models. Images were taken with a Ricoh R8 compact camera by Joachim T. Haug, assisted by Gideon T. Haug, without any further devices such as external flashes or tripods. Images were recorded under cross-polarised light, provided by the built-in flash (HaugJT & HaugC 2011, Fossilien 3/11, 159–163). Each specimen was documented as a stereo image: two half images were recorded "free-handedly" under slightly different angles. Reference to the specimens is given as: repository number and/or name; location, country; estimated age. In some specimens, reference to their immature state is given behind the name. Abbreviations: a = annus = year; Ma = Mega anni = one million years. This presentation was prepared by Carolin Haug and Joachim T. Haug and is intended for non-profit purposes only. For further information about the presenters visit: http://palaeo-evo-devo.info/. For further information about the excellent permanent exhibition in The David H. Koch Hall of Human Origins at the Smithsonian National Museum of Natural History visit: http://humanorigins.si.edu/research.