DEVELOPMENT OF A TRUE-3D ANIMATION OF LANDSCAPE FORMATION AND COMPARISON TO OTHER GEOLOGICAL VISUALIZATION METHODS. EXAMPLES: "SAXON SWITZERLAND" (GERMANY) AND MAULE (CHILE)

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Abstract

Geological issues, phenomena and processes – geology in general – can be visualized in several ways. Five feasible options were specifically investigated and compared with each other in regard to three-dimensionality and spatio-temporal change: a geological map (2D), a lenticular foil map with three-flip (true-3D), a physical geological model/puzzle (true-3D), a non-temporal computer animation (pseudo-3D) and a temporal computer animation (true-3D).

The chosen examples represent either the Saxon Switzerland National Park in the east of Germany or the Maule Region in central Chile – two areas with highly different reliefs. Considering these areas allows the 3D visualization of both the enormous terrain altitude differences of the Chilean Andes and the smaller but distinctive rock formations and table mounts of the Elbe Sandstone Mountains enabling the viewer to get the best possible impression of depth.

Special focus is put on the practical implementation of the landscape formation of the Saxon Switzerland National Park applying a lenticular foil map and an autostereoscopic computer animation. The main theme in both visualizations is the development of the relief, in particular the changing course of the Elbe River within the national park over the last 2.4 million years. The combination of an up-to-date digital elevation model (DEM) with geological maps and publications as well as drill core data provides the possibility to travel backwards in time until the beginning of the Ice Age.

1. Introduction

Geology is a means of investigating the history of our planet earth and the history of life on earth. Nearly every natural history museum therefore includes geology in its exhibitions. Geological maps, however, are often too complex and too difficult to read for the ordinary visitor of a museum. To understand the processes of formation history of a region more easily, other possibilities to visualise these processes were evaluated and compared to one another.

The following kinds of visualisation were made and compared with one another for two different exemplary regions, Saxon Switzerland in the east of Saxony in Germany and the region Maule in central Chile:

- geological map of the Maule region (2D)
- lenticular foil map with three-flip of the changing course of the Elbe river (true 3D)
- physical geological model/puzzle of the area around the Elbe river/Saxon Switzerland (true 3D)
- non-temporal computer animation of the Maule region (pseudo 3D)
- temporal computer animation on autostereoscopic display of the changing course of the Elbe river (true 3D)

Saxon Switzerland, a landscape formed by erosion within the Mesozoic era (more precisely: late Cretaceous, 100 million years ago) consists of deposits that are 600 metres high (Hübner et al. 2006). The present day landscape was created by the Elbe river. Table mounts and deep valleys with height differences of about 450 metres characterise the appearance of Saxon Switzerland. The Maule region in Chile, a landscape shaped by the Andes, contrasts Saxon Switzerland with height differences of about 4000 metres. The beginning of the formation of the Andes reaches back to the Jurassic, 150 million years ago, when the oceanic Nazca Plate began to move underneath the continental South American Plate, and that process still continues today, with the region being a volcanic area. Thus, a great deal of the bedrocks are comparatively young, they reach back to the Cenozoic.

2. Comparing the visualisations

Comparing the different kinds of visualisation shows that each way of presenting the geology of a specific region has its benefits and drawbacks. The 2D geological map has the great advantage of very high resolution and precision and thus presents a good means of interpretation for experts. Therefore the 2D map may not be the best visualisation for exhibitions but rather for workshops or seminars.

However, when it comes to showing the development of a region or to the presentation in 3D, the 2D map is not sufficient. For these requirements the lenticular foil map with its three-flip seems to be the better solution (Fig. 1 – Fig. 3). Still the technical possibilities to show the development of time and space in 3D are limited since only up to three different moments in time may be realised in 3D today. The effect of true 3D is more attractive to visitors of a museum and is therefore preferable. It takes less cognitive effort to imagine the relief. However there are also disadvantages of true 3D. While generally the effort of decoding lenticular pictures is similar to ordinary maps, the extrinsic (from the outside) strain is higher because of the optical-physical depiction premisses. The general reduction of the definition (with two parts of one picture the sharpness of the original maps is reduced by half) and “ghosting” (intersection of parts of the pictures) could lessen the information content (Dickmann et al. 2012).

Of course the physical model is best to create the 3D effect. The possibility to touch the model and even put it together by oneself is a great means to increase both interest and learning curve. Especially for children, for whom maps might be too difficult to understand, a physical model is most suitable. Yet the formation process of a landscape cannot be shown by a static model. Furthermore, the physical model can never be completely precise because some parts of it must have a certain size so they can be physically built.

These inaccuracies do not occur with computer animation. The non-temporal computer animation makes it possible to watch the flight towards or across a landscape but it cannot show the temporal development of the landscape. However, by using large parts of the so-called monocular depths cues (Buchroithner 2002), a so-called pseudo 3D presentation is created, which helps the viewer immensely to imagine three dimensionality.

This kind of visualisation is only exceeded by the temporal computer animation, which includes the time level. Showing an animation as true 3D film on an autostereoscopic display increases its attractiveness and may raise the curiosity of museum visitors, experts and children alike. At the same time a 3D film can be a nice change from reading all the texts that are necessary to understand certain facts. The visualisation by computer animation, whether true or pseudo 3D, can also be supported by sound and is especially suitable for exhibitions in museums. A disadvantage of the autostereoscopic display however, similar to the lenticular foil map, is that it does not reach a high level of sharpness. Furthermore, the number of viewers is limited. So the true 3D effect is not automatically in advantage to the pseudo 3D presentation when it comes to flights towards, across or through a landscape (while static 2D pictures compared to 3D pictures are definitely in disadvantage). Even though all depth cues of both monocular and binocular viewing may be used and the 3D effect is definitely impressing, there is not necessarily an added value of information for the museum visitor.

In most cases the combination of different possibilities of visualisation is the best solution. For example an animation film may be projected onto a physical relief model so that 3D and the formation process of a landscape are combined and can be shown more accurately. For the future it would be desirable to continue the empiric research of comparing the different possibilities of visualisation and test the effects of the above examples with museum visitors.

3. Workflow, implementation and results

To create the animation drill core data and geological maps were analysed and used in ESRI ArcGIS and in the 3D software Blender. The Saxon Switzerland region being the area in Europe where the most drilling has taken place was a great advantage because a lot of drill core data were available for analysis. Step by step these detailed pieces of information were combined with further information about old courses of the Elbe river published by Wolf & Schubert (1992) and Lange (2012). This way it was possible to reconstruct the changing relief of the last 2.4 million years.

The parts of the pictures needed for the lenticular foil map could be produced with Blender. The animation had to be exported into the proprietary 3D graphic software Cinema 4D because here the required plugins for creating the 3D effect were available. Blender is a freely available software, which is why it was chosen at the beginning of this project. The implementation for an autostereroscopic display would have been possible with this programme, but far more complicated than with Cinema 4D. The company that produces the autostereoscopic display “Tridelity” offers plugins for Cinema 4D and Adobe After Effects (used at the end for the edition and the insertion of texts), which makes the production of the 3D effect a lot easier.

During the development of the animation some irregularities emerged concerning the relief heights of the old courses of the Elbe river by Wolf & Schubert (1992) and Lange (2012). Here some more research by geologists is needed to verify the data, for example with further drilling.

However, the presentation of the past naturally becomes more and more inaccurate the further we go back in time. Furthermore, geology in general has to deal with inaccurate depths data. The deeper the presented formation, the more guessing is involved. Thus the final result is a graphic animation, which presents the geological development of the region during the last 2.4 million years based partly on comparatively few data and partly on suppositions. It was created within a short period of time and by using just the tools which were available at TU Dresden – ESRI ArcGIS, the 3D Graphic Softwares Blender, Cinema 4D and Adobe After Effects. Expensive 3D modelling softwares for geology like GOCAD were not used at all.

The result of the lenticular foil map is a good one. Although, when watching one of the three flips the sight lines are very narrow, all three Elbe courses can be well recognised after some time of adjustment. With 4 mm depth difference (DIN A5) there is not a big 3D effect, but for the format being quite small the result is still a good one. In addition, it does not look as super elevated as is the case with some 3D relief cards.

The autostereoscopic visualisation via the ML4210va display by Tridelity has not much been used at TU Dresden yet, so the film can be seen as another object of research concerning the usage of this technology. Settings have been found which enable the optical elevation of the model from the display. The basic requirement here is that the model does not "touch the edge" of the display since otherwise different depth criteria contradict one another. Furthermore "real facts" that have a big effect of depth during the flight through the Elbe valley have been successfully implemented. At this point further expert knowledge and research is needed especially concerning text fade-ins. The goal must be to be able to position these fades-ins within the desired distance from object and display at once without longer trial. Also the effects of the distance of the camera in Cinema 4D for the 3D screen need more experience to be used more expertly. For example the presettings of 6.5 cm show no visible 3D effect in such big ground models.

4. Outlook

For the future visitor of a natural history museum an interactive autostereoscopic display would surely be another attraction. With the movement of the hands in front of its eyes the visitor could (with zoom and pan) move freely within the model itself, he could let the desired stratigraphic layers be shown or hidden or he could move a time line where he wants it to be. Research of this kind is already being carried out at the Fraunhofer Institut für Nachrichtentechnik, Heinz Hertz Institut, but it is not yet available for the wider public.

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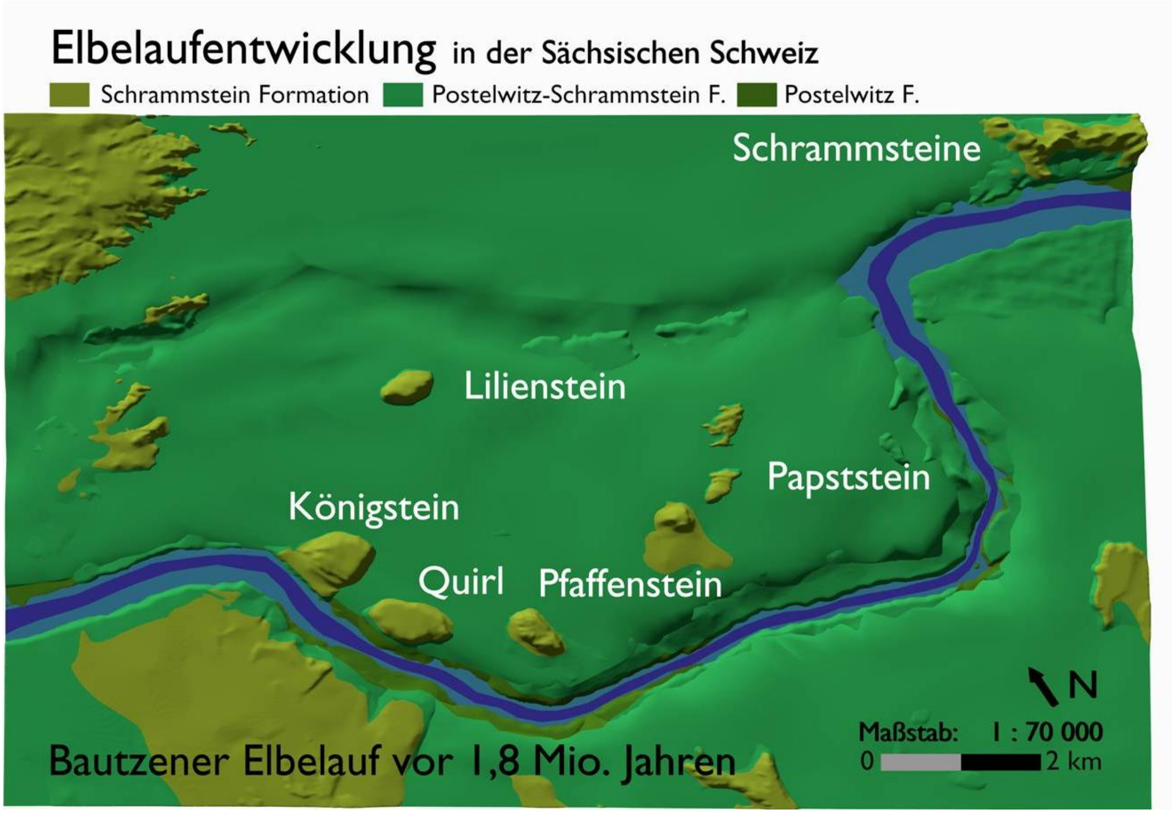

Figure 1: First flip of the lenticular foil showing the course of the Elbe river 1.8 mya

Figure 2: Second flip of the lenticular foil showing the course of the Elbe river 1 mya

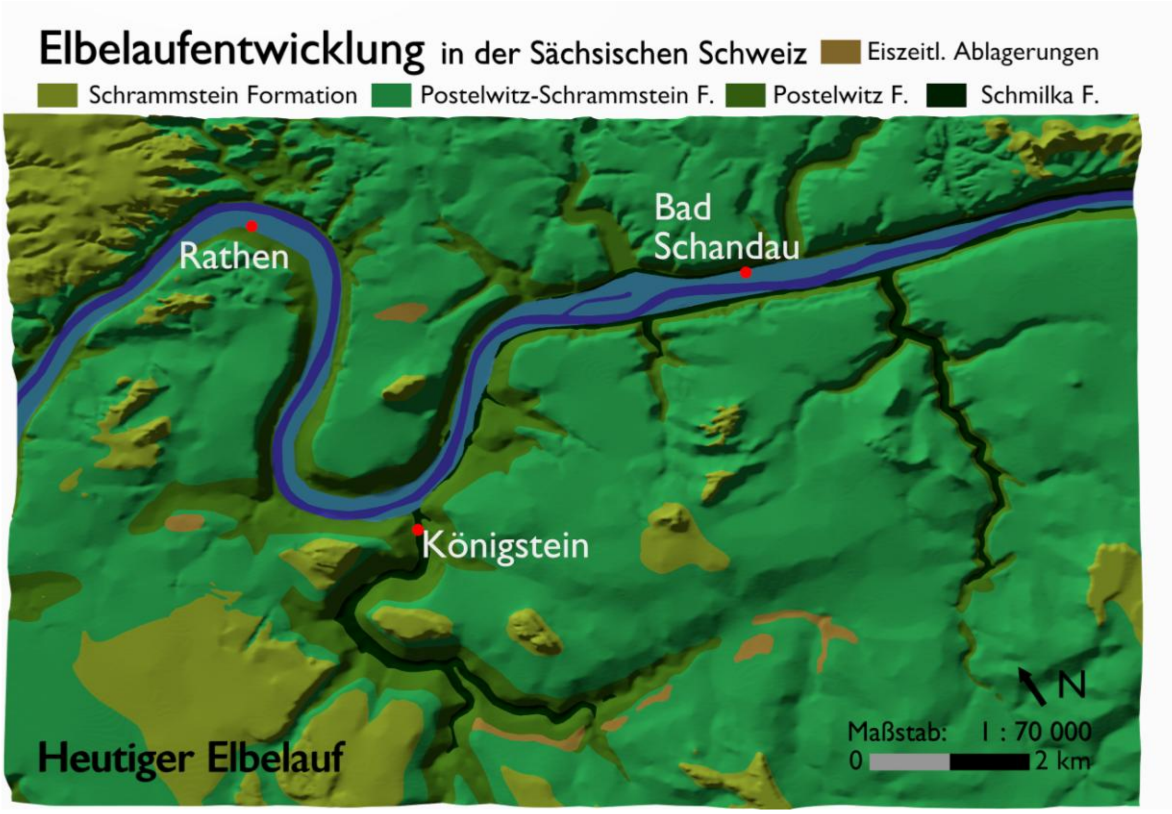

Figure 3: Third flip of the lenticular foil showing the present-day course of the Elbe river