CO-015

3D SURVEYING AND VISUALIZATION OF THE BIGGEST ICE CAVE ON EARTH

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ABSTRACT

The paper deals with the first three-dimensional TLS Surveying of the biggest ice cave on earth, the Eisriesenwelt in the Austrian Alps. The various steps of data acquisition, data processing and visualisation are described. One of the major outcomes of the project is that the previously totally unknown ice surface amounts to 27,890 m². This value is supposed to represent the outset of future ice monitoring activities.

INTRODUCTION

In times of Global Warming all aspect related to water issues are gaining importance. Hence, not only the scientific community but also the public got very much interested in the extension of the glaciers of a global scale. Subterraneous ice masses have so far, however, not yet been exploited in a quantitative way. The current study represents a first approach in this direction.

It has to be noted that, once we talk about ice caves, we have to distinguish intraglacial caves within glaciers and rock caves filled with ice. In the present case we are dealing with the latter type.

Figure 1: General overview showing the cave entrance in the steep rocky face of the Western Tennengebirge (Tennen Massif), approx. 50 km south of the City of Salzburg, Austria, taken from the closest geodetic survey point (foreground).

THE ICE CAVE

It is the unanonimous opinion of all experts, that the Eisriesenwelt ("Ice Giants' World") represents the biggest ice-filled rock cave on earth. It is situated some 50 km south of the City of Salzburg, in the Austrian Tennengebirge, a karstic mountain massif. In its ice-filled part it is a touristically developed and commercially managed cave. According to the cave management, until recent the estimates of the ice covered area in the Eisriesenwelt reached from "close to 10,000 m²" to "mode than 40,000 m²": This implies a discrepancy of more than 400 percent!

The cave ice represents the tourism potential of the whole region. Now the question arises how the dynamics of the ice coverage are developing during the current Global Warming. Is the ice retreading? Or

is even an inversion effect occurring? A first reference survey was supposed to clarify these questions and to serve as a basis for a subsequent ice monitoring.

The entrance of the cave at an altitude of 1641 m can be reached via a curvy tar road up to the visitor centre (1000 m). Than a 20-minutes hike leads to the bottom station of a cable car (1080 m) which brings the visitors to the top station near an old Austrian mountain hut (Dr. Oedel House 1575 m) which also served as the base for the surveying campaign in April 2010.

The ice-filled part of the Eisriesenwelt is slightly more than 1000 m long and extends over a vertical distance of 134 m.

3D-SURVEYING CAMPAIGN

Based on the experiences acquired during a 3D cave surveying campaign in the Dachstein Massif of the Austrian Alps, the author has been approached by the management of the Eisriesenwelt whether he would be willing to make a first survey of its ice area (The results of this expedition were published in an article by Buchroithner and Gaisecker, 2009.)

Under the direction of the author, during one week two 4-person teams of Cartography students from the Dresden University of Technology, supported by three professional cave guides and a TLS expert from FARO Corp. have been involved in surveying activities under comparatively harsh conditions. Temperatures below zero (Centigrade) and comparatively high air humidity represented a difficult environment for both personnel and instruments. Starting at the entrance and the very end of the ice-covered area, the two teams employed two terrestrial laser scanners FARO Photon 20/120 with 35 kg each. In addition, two car batteries with 25 kg each and two laptop computers with approximately 2 kg each had to be carried to the various surveying points.

The FARO Photon 20/120 allows to cover 360° with an infrared laser-beam. The applied ¼ resolution with 244,000 points per second results in a scan period of 3 minutes 24 seconds per scan. In order to assure that the laser beams capture the "actual" ice surface and do not penetrate into the ice, on initiative of the author prior to the field campaign in cooperation with a physicist of FARO Corp. tests were carried out which yielded positive results.

Apart from the laser scanning surveys, big parts of the cave were measured in a conventional way by means of a reference tape (Fig. 2).

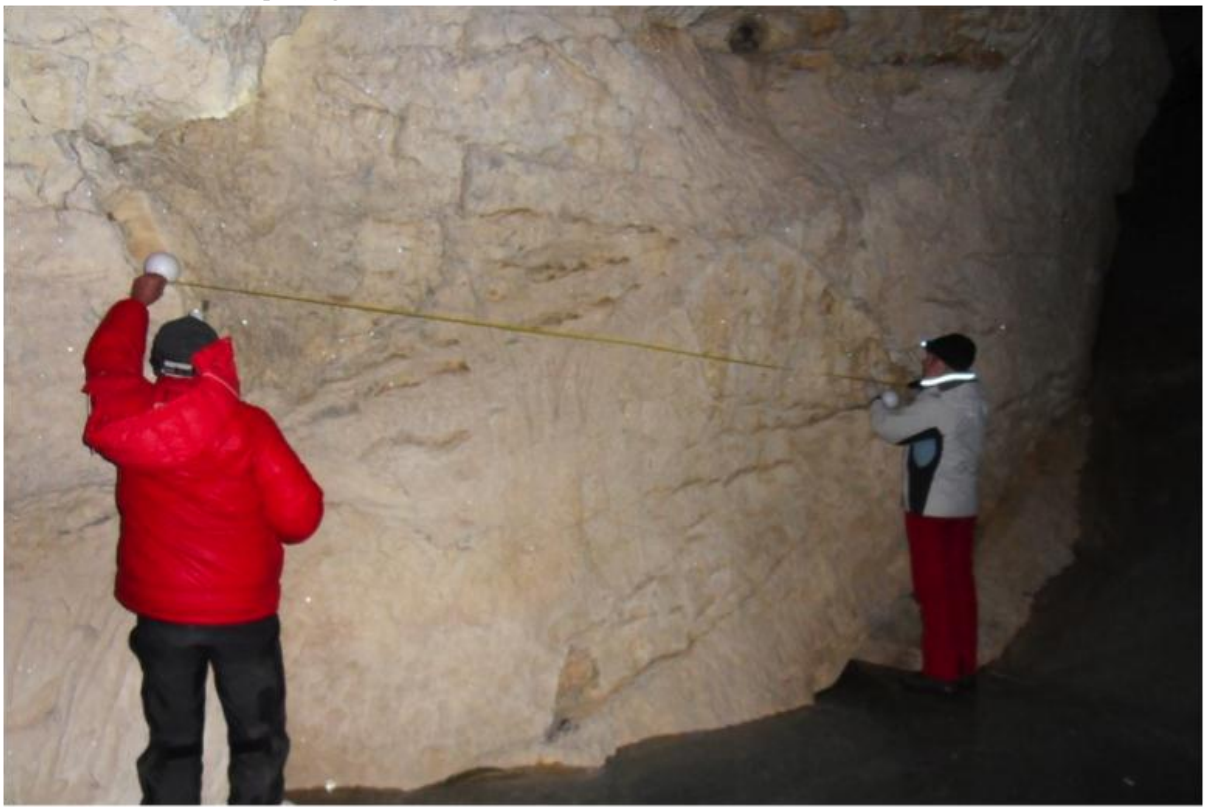

Figure 2: "Classical" tape measure surveying of the styrofoam reference globes.

Prior to the actual cave surveying a set of highly accurate measurements to and from defined surveying points of the official Austrian Geodetic Network had to be accomplished, in order to allow the attachment

of the cave surveys to the Austrian Geodetic Network (Österreichisches Bundesmeldenetz). Inside the cave in total 158 360°-scans and approximately 200 high-resolution photographs (texture imagery) with more than 28 Gigabyte of data were acquired (Fig. 3 and 4).

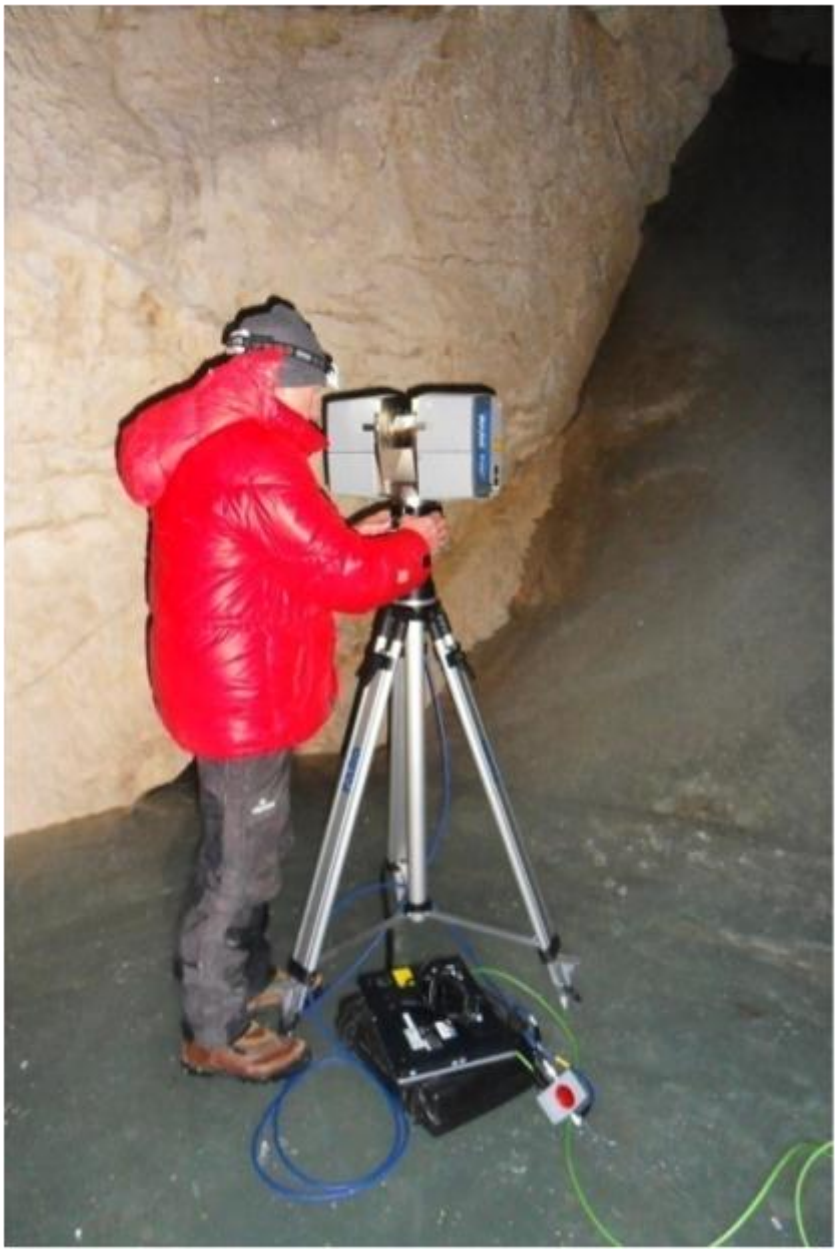

Figure 3: The author operating the FARO Photon 20/120 on the cave ice surface.

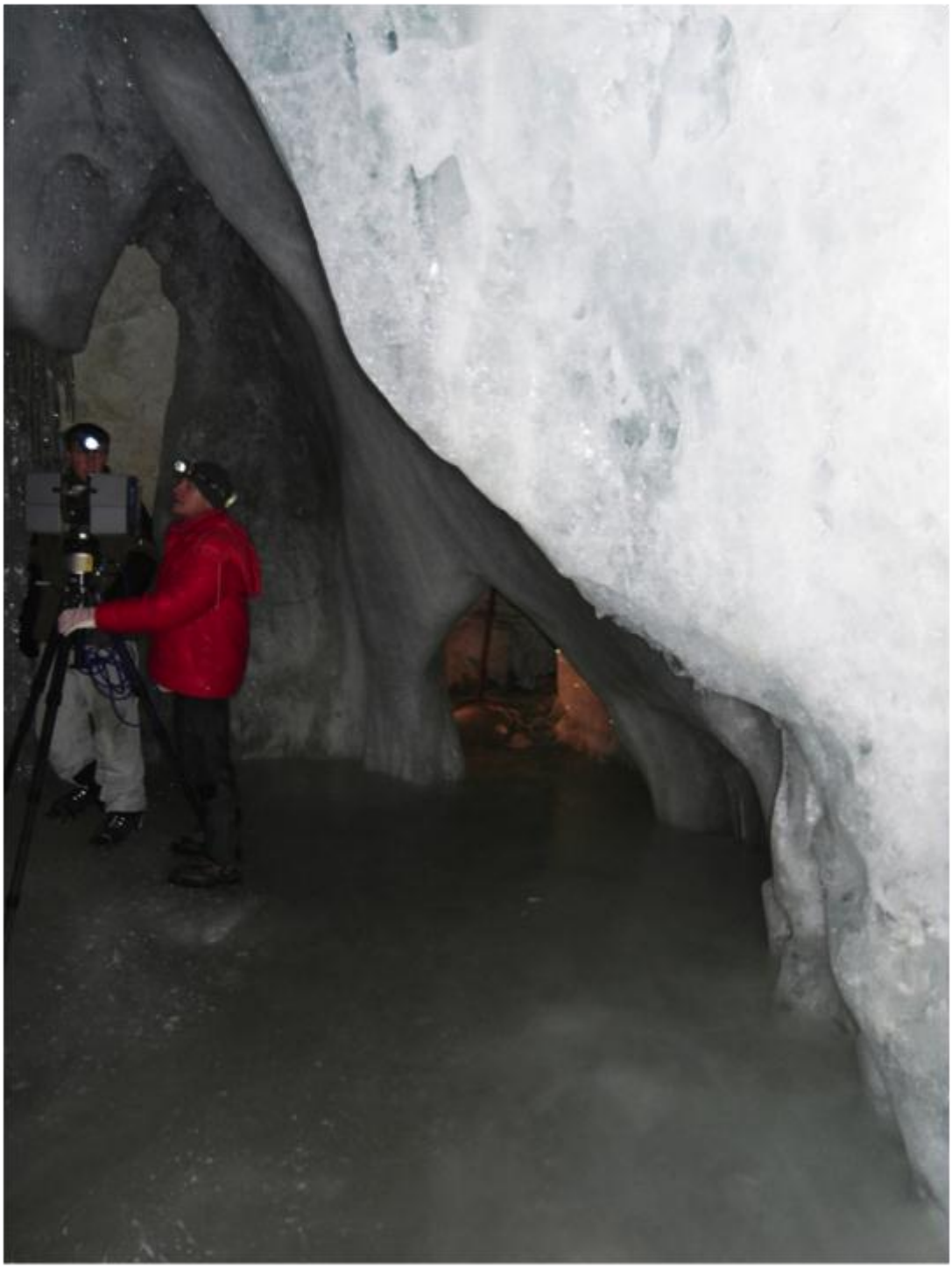

Figure 4: Some portions of the Eisriesenwelt represent real labyrinths of ice. A multitude of TLS scans are required to reflect the real-world conditions.

Apart from the demanding accuracy requirements, also the physical/alpinistic capabilities of the surveying teams had to cope with exceptional conditions (Fig. 5). So, in many instances the styrofoam target globes had to be placed at particular spots on the ice which could only be reached using alpine gear, i.e. crampons and ice axe. Over hundreds of meters the wooden visitor gangway, which comprises more than 1400 steps, had to be cleared from thick ice covers with pickaxes.

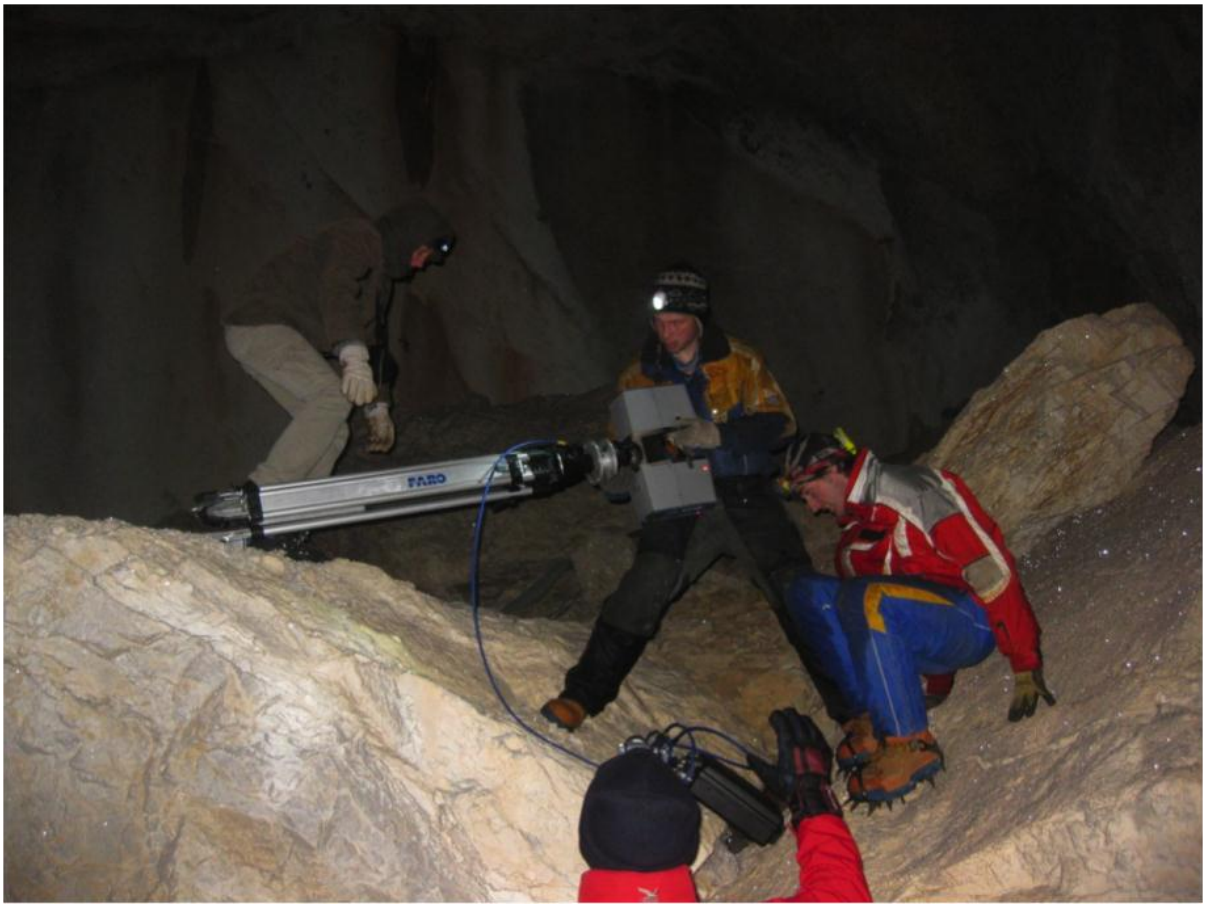

Figure 5: Demanding work to mount the TLS at the required positions.

DATA PROCESSING AND 3-D VISUALISATION

As already mentioned the total amount of data was more than 28 Gigabyte. This implies a rather sumptuous data processing. The final goal was a photo-realistic 3D-model of the Eisriesenwelt, which – following the idea of cross media visualisation – should than be depicted in different ways. It is envisaged that apart from a "classical" planimetric map a set pseudo- and true-3D visualisations shall be generated. The management of Eisriesenwelt plans to put fly-through simulation onto their website. In addition, autostereoscopic screens – e.g. at the cave's visitor centre – can be used to display the cave in "true 3D". Hardcopies based on lenticular foil technology can be produced in various formats, e.g. as picture postcards allowing autostereoscopic viewing.

First calculations resulted in a total ice surface of 27,890 m², thus being in between the two extreme estimates mentioned above (see Section 2). This value can be seen as a reference and an outset for further monitoring surveys. Figure 6 may serve as an example for the TLS- and image data taken from one of the 158 survey points.

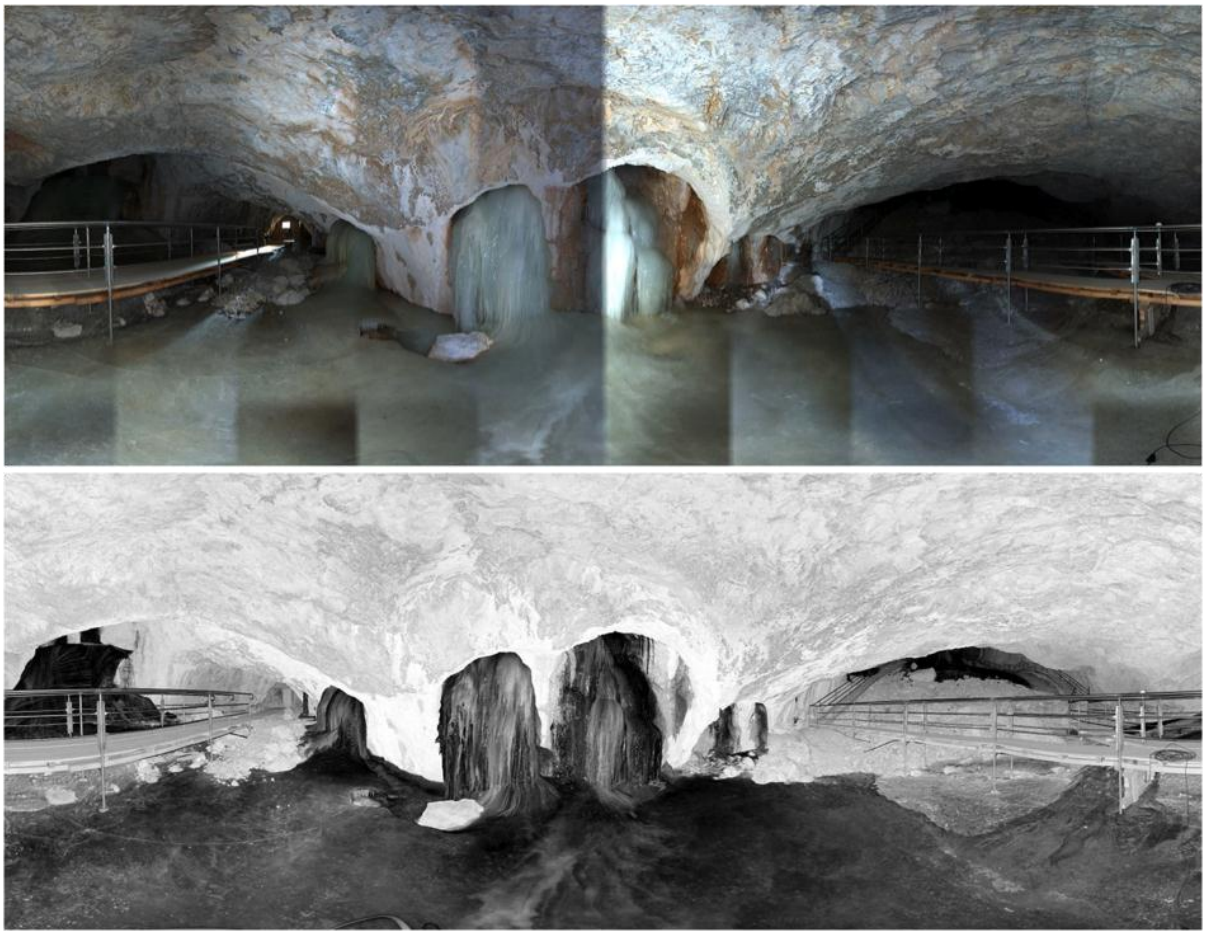

Figure 6: Depiction of both a TLS scan using FARO Photon 20/120 in the outer Eisriesenwelt, taken 7 April 2010. Top: Point cloud. Bottom: Synchronously taken digital photograph for texture draping.

REFERENCES

Buchroithner, M. F. & Gaisecker, Th., 2009: 3D Surveying and Visualisation of a Complex Dome in an Extreme Alpine Cave System. Photogrammetrie, Fernerkundung, Geoinformation (PFG), 4: 327-337.