The WAVE and 3D: How the Waters Might Have Parted—Visualizing Evidence for a Major Volcanic Eruption in the Mediterranean and Its Impact on Exodus Models

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Abstract

To fully engage in Late Bronze Age "world building" and the Exodus narrative for the EX3 exhibition (see Chap. 11), transdisciplinary research in archaeology, geology, and computer graphics were integrated in a new 3D immersive Wide Angle Virtual Environment (WAVE). The goal was to marshal geological evidence for a hypothesis that might explain the "Parting of the Sea" narrative in the Book of Exodus. The research explores the possibility of a connection to the Santorini island (Thera) volcanic eruption of the Late Bronze Age inducing a tsunami that would first draw the water away from the shore before surging back into a large wave. We collected data from various sources and geo-located it on a 3D map of the Mediterranean region. Combined with an automated presentation sequence and narration, the resulting virtual reality application presents the data in a novel way, which allows for a more intuitive approach for its interpretation. This chapter introduces the new WAVE and describes how we created a real-time virtual reality demonstration to present archaeological and geological data that may inform elements of the Exodus story. We explain how the data was acquired, how it was fused onto a 3D terrain map, and how an automated demonstration was created with narration for the Exodus exhibition. The chapter examines the scientific features of the visualized data, as well as the implementation of the visualization software.

Introduction

By utilizing the power of 3D scientific visualization, ancient "world building" of the ancient Hebrew Exodus from Egypt was empowered at an unprecedented level. EX3 researchers explored environmental hypotheses linking Late Bronze Age tsunami events to the "Parting of the Sea" narrative in the Book of Exodus. Earlier researchers have studied geological influences on a range of events mentioned in ancient texts and/or observed in the archaeological record. Manfred Bietak (1996) excavated the ancient city site at Tell el-Dab'a (Avaris) along the now extinct Pelusiac branch of the Nile River, identifying the city as a harbor town. Daniel Jean Stanley (Stanley

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et al. 1996; Stanley and Warne 1993a, b) collected and evaluated sediment cores in the Nile Delta to reconstruct the location of the Nile paleo-coastline of the Late Bronze Age, putting it farther south along its eastern flank. Stephen Moshier (Moshier and El-Kalani 2008) describes the geomorphic evidence for a northern Exodus route. Stanley also evaluated sediment cores in Lake Manzala containing volcanic ash deposits from the Thera volcanic eruption of the Late Bronze Age (Stanley and Sheng 1986). And Floyd McCoy, B. Goodman-Tchernov, Steven Ward, and T. Novikova have each collected and modeled evidence for a resulting tsunami from the Santorini (Thera) eruption that should have reached the ancient Nile coastline (Goodman-Tchernov et al. 2009; McCoy and Heiken 2000; Novikova et al. 2011). Each of these pieces of evidence has been integrated with to archaeological and biblical research on the Exodus (Sivertsen 2009), but never before have they been united into one scientific data visualization. Only Moshier had created a geospatial digital database of his work. Most other research results exist in scientific papers, but not in any digital or geospatial database. The WAVE immersive visualization environment provides a discipline-neutral platform for combining these data into a space that allows several people of different disciplines to collaboratively evaluate the data. Doing so has illuminated correlations that had not been made before.

The following sections of this chapter provide an overview of work related to our project, explain the various data types that went into our visualization application, how we processed them, and how we fused them into one application. We then report on how we turned the visualization application into an exhibit-ready demonstration, and we summarize what we learned from the experience.

Wave Construction and Geometry

The concept of an LCD-based virtual reality system such as the WAVE is described in a publication by DeFanti et al. (2011), which compares LCD-based systems to the traditional projector-based ones and finds that LCDs have significantly higher contrast and brightness, are easier to maintain, and have much smaller overall space requirements (Figs. 12.1, 12.2, 12.3, and 12.4).

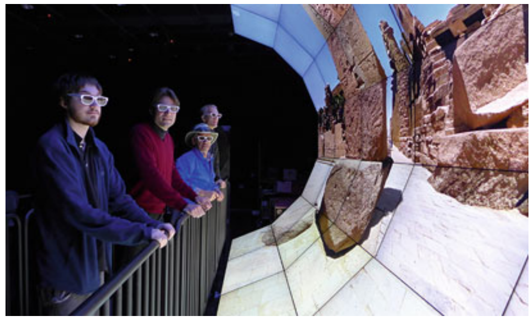

Fig. 12.1 WAVE with researchers Chris McFarland, Jürgen Schulze, Greg Dawe, and Falko Kuester. Photo by Tom DeFanti

The University of California – San Diego's new WAVE display, true to its name, is shaped like an ocean wave, with a curved wall array of 35 55″ LG commercial LCD monitors that end in a "crest" above the viewer's head and a "trough" at his or her feet. It was fitting that the WAVE display was inaugurated at the EX3 exhibition featuring world building around the routes of the Exodus and the "Parting of the Sea" (Exodus 14) and the "museum of the future." The WAVE was designed by Tom DeFanti, Falko Kuester, and Greg Dawe. The WAVE, a 5 × 7 array of HDTVs, is now 20′ long by nearly 12′ high and can accommodate up to 20 people. Its curvature makes it appear like the department store windows of yore, or museum dioramas, in which the glass is positioned away from you and you cannot touch it, so it does not feel like it is there. The WAVE achieves that illusion in ultrahigh resolution (35 times 3D HDTV). Its curved aluminum structure is also a technical solution for the problem of the upper and lower parts of images on 3D passively-polarized screens ghosting as double images when simply mounted flat on a wall.

High-resolution computerized displays have evolved over the past decade from 2D to 3D panels and from one monitor to arrays of many monitors. They have transitioned from thick bezels (the rim that holds the glass display) to ultra-narrow bezels. Such technology is now widely used in television newsrooms, airports,

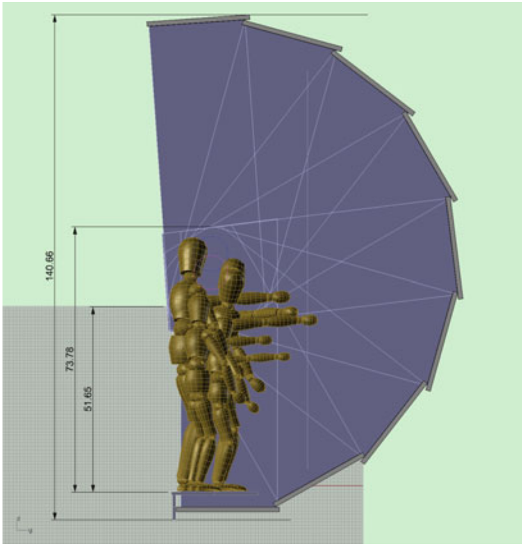

Fig. 12.2 CAD drawing of the WAVE design by Greg Dawe

Fig. 12.3 WAVE under construction for Exodus with Chris McFarland, Greg Dawe, and Andrew Prudhomme. Photo by Tom DeFanti

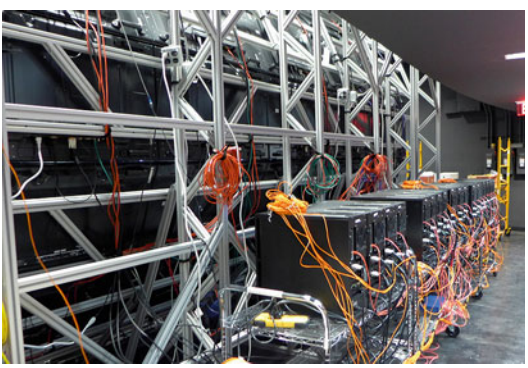

Fig. 12.4 WAVE computers as built by Joe Keefe, Chris McFarland, and Eric Lo. Photo by Tom DeFanti

and even retail stores, but not commonly in 3D like the WAVE.

With the creation of the WAVE, we wanted to give people an experience of looking over the edge, of hanging off a railing like you might do at the Grand Canyon. To do that, we had to provide an image above and below the viewer. When the data comes up and the ground plane disappears underneath you, it really feels like you are "flying over the data."

Related Work

The software we use as the basis for the development of our visualization application is built on top of our own CalVR (Schulze et al. 2013), which in turn uses the OpenSceneGraph API (OSG 2013) as its graphics engine and osgEarth (OSGEarth 2013) as its terrain rendering subsystem.

Our team has many years of experience with visualizing archaeological data in virtual reality. Notable publications include our *PNAS* paper by Levy et al. (2008), which mentions the use of our StarCAVE for a visualization of an excavation site in Jordan. More recently, Lin et al. (2011) have presented a virtual reality visualization application for an archaeological survey site in Mongolia.

Related work by other groups includes Vote et al.'s article (2000) on ARCHAVE, which is to our knowledge the first successful data visualization project for virtual reality in archaeology, using excavation data from the city of Petra in Jordan.

The proceedings of the annual International Symposium on Virtual Reality, Archaeology, and Cultural Heritage (VAST) provide a good source of a variety of case studies in the area of archaeology visualization projects. However, the projects presented there are typically on specific sites of archaeological interest, or technology related to data acquisition.

Research in landscape visualization has traditionally focused on policy and decision-making for environmental issues and urban planning (Dockerty et al. 2005; Block 2007; Sheppard 2005), which has been limited to static landscape design under different scenarios. More recently, with the broad use of Google Earth and ESRI's ArcGlobe, geospatial research has transitioned to the use of virtual globes to display and analyze geospatial data at various scales (Tomaszewski 2011; Tiede and Lang 2010; Smith and Lakshmanan 2011). However, these platforms have their limitations in data manipulation and accessibility. Most of this past research has focused on one geospatial scale, whereas our project took advantage of both local and regional data. Rarely have virtual globes been used to compare past and present geographies (Yano et al. 2012). The Kyoto case by Yano uses the virtual globe to show static images of different years. To our knowledge, we are the first to ever create a virtual reality demonstration of possible Exodus scenarios. The advantages of the osgEarth platform are its open source availability and functionality to manipulate all aspects of the geospatial data including topographic resolution and animation. With these functions, we were able to uniquely display information from a local to regional scale while adding 4D animations, and automated flight paths with narration.

The Exodus Data Fusion System

The platform in which the Exodus immersive visualization was developed was Qualcomm Institute's own virtual reality framework, named CalVR. CalVR is middleware software and facilitates writing applications for virtual reality systems by logically separating display configuration, rendering cluster and input devices from the application: the programmer can develop the application on a desktop computer, and later run it, normally without further modifications, in a large, graphics-cluster driven virtual reality (VR) system. CalVR is entirely written in the programming language C++ and uses the OpenSceneGraph API (OSG) as its graphics interface.

The terrain rendering engine, osgEarth is used to display the Mediterranean region and all geospatial data. osgEarth takes care of dynamically paging in the levels of detail of the terrain needed for a certain camera view: things in the foreground are rendered with greater detail than things at a distance. This allows us to maximize visual fidelity with a given hardware configuration. Note that it would not have been possible to use Google Earth for this application. While it is very similar to osgEarth in many aspects, Google Earth would not have run on the WAVE with its unusual screen configuration and head-tracked stereo vision.

Our goal was to merge (fuse) all of the available geographical data regarding the Exodus onto a very detailed 3D map of the region. We targeted this application for our newest walk-in virtual environment, the WAVE. Because the application was to be shown as part of the Exodus exhibition, we created an automatic, prerecorded demonstration mode with a voice-over, so that visitors only had to put 3D glasses on and watch the 8-min presentation. But even in demonstration mode, the application renders all the graphics in real-time and could be interrupted at any point to manually take over the camera controls—similar to turning off the autopilot in an airplane and flying it manually. The manual mode is useful for archaeologists to study the fused data in greater detail than is possible in the automated presentation, and also at their own pace.

Regional Geographic Base Map: Terrain and Imagery

Global terrain data was downloaded and merged from the US Geological Survey (USGS) and National Geospatial Intelligence Agency (NGA) Global Multi-resolution Terrain Elevation Data (GMTED) at a resolution of approximately 30 m per pixel. To make the topography complete, Mediterranean seafloor bathymetry was downloaded from the European Marine Observation and Data Network (EMODnet) (http://portal.emodnet-hydrography.ed/#) and merged with the land surface topography. These data provide the topographic basis for all other geospatial data to be evaluated. It provides depth to the seafloor, distance from the volcanic eruption to the Nile coast, and shows how and where a volcanic eruption and resulting tsunami could have traveled with topographic constraints. Global satellite imagery was draped over this topography in osgEarth using a Web map service (WMS) from readymap.com.

Four tiles of the USGS dataset comprised the entire land surface topography including the Mediterranean, Europe, and the Middle East, which we into merged a single regional file and then trimmed to our area of interest. Of the bathymetry data, each subset of the Mediterranean bathymetry was downloaded from the EMODnet data portal as an ESRI GRID format, reprojected to WGS84, resampled to a spatial resolution 30 m per pixel to match the terrain, and merged to the regional file. The completed terrain with all files were processed and merged, then exported into a 16-bit floating GeoTIFF-formatted file. This preprocessing workflow was performed using ESRI's ArcMap to prepare the data for the osgEarth software in the WAVE. Challenges of file size were encountered on the desktop PC used to run ArcMap. Solutions around this were made by cutting areas surrounding the study area before merging the complete file.

Modern satellite imagery was draped over the regional topography using a web map service to provide context for the regional fly-through. The specific data chosen from ReadyMap has been color-matched globally so as to provide visual continuity from the global, zoomed-out view to the zoomed-in, local views across the Nile Delta and the Sinai Peninsula. The compromise for choosing this coarse resolution dataset is that we do not see detail of current cities or urban infrastructure in the imagery as we zoom in. However, for this project that works in our favor. We successfully used present-day imagery to present Bronze Age information without interference of present-day anachronisms. An additional advantage to using the WMS is to save local memory for other data (Figs. 12.5 and 12.6).

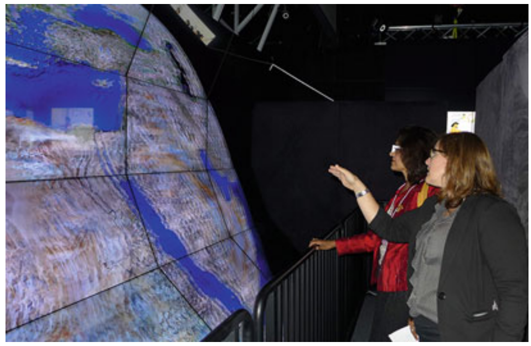

Fig. 12.5 WAVE with researchers and audience during Exodus exhibition. Photo by Tom DeFanti

Fig. 12.6 WAVE from above. Photo by Tom DeFanti

Geological Data: Nile Sediment Drill Cores

Research published by Daniel Stanley was a result of the Smithsonian Institute's Nile Delta Drill Core and Sample Database (Stanley et al. 1996) to collect and log 87 sediment cores along the northern Nile Delta plain. The cores were drilled between 1985 and 1990, and subsequent lithologic logs (sediment description throughout each core) were created. Data for each core was collected including core number, core length, date of core recovery, approximate location description, and latitude and longitude with each lithologic log. These data provide the rock record to place the location and evolution of the Nile coast over the last 4,000 years. The coast evolution was reconstructed by Stanley (Stanley and Warne 1993b) and then digitized in ArcMap by the authors of this chapter using the figures in Stanley's paper. Reconstructing and visualizing the ancient topography is critical to addressing reasonable escape routes for the Hebrews (see Figs. 12.9 and 12.10).

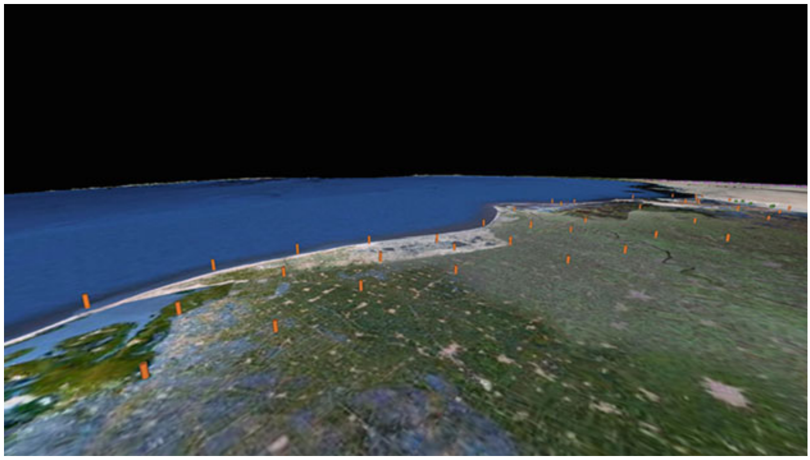

Fig. 12.7 Sediment cores along northern flank of Nile Delta displayed in osgEarth

The core latitude, longitude and core length of each location were transcribed to Excel and then imported to ArcMap as a shapefile. That shapefile was then imported to osgEarth to be represented as 3D cylinders with uniform radii and varying depths depending on the length of the core. The 87 drill cores in the Nile Delta plain were colored bright orange (Fig. 12.7), and the 5 drill cores in Lake Manzala were colored a yellowish orange. For the purpose of being able to see the variation in core depths from the Earth surface, we represented these variations by extruding them above ground using their depth value (rather than representing them in the subsurface).

Stanley collected an additional five drill cores in Lake Manzala just east of the Nile Delta plain. These core locations were digitized using Stanley's map in ArcMap, and the exported shapefile was added to osgEarth as a separate file. These five locations contain the volcanic ash with characteristics matching the Thera volcanic eruption of the Late Bronze Age (Stanley and Sheng 1986). The Lake Manzala cores provide correlative evidence for how and where the volcanic ash from the Thera eruption affected the Nile coast.

Geophysical Data: Volcanic Eruption Simulation

Geophysicist Steven Ward of UC Santa Cruz used computational fluid dynamics modeling to create hypothetical, but geologically plausible, scenarios that could induce a tsunami in the Mediterranean Sea. He provided a scenario where a plinian volcanic eruption on Santorini induces a wave to propagate from the island southeastward, through the narrow outlet between the Greek islands of Crete, Karpathos, and Rhodes; ultimately arriving at the Egyptian and Israeli coasts. This simulation, shown on a virtual Earth, sheds light on the physical possibility of a wave in the Aegean Sea reaching 800 km across the Mediterranean to the Nile Delta. Although several geological processes could induce a tsunami in the Mediterranean Sea including a submarine landslide, a storm surge, a Hellenic subduction zone earthquake, and a Theran eruption, we chose to display and animate only the Theran eruption to represent the maximum amount of research discussed at this meeting.

To enhance the animation of the tsunami, we added a schematic ash plume at the location of Santorini island to initiate Ward's simulated wave animation. The height of the plume was animated to represent 35 km above sea level to correlate with prior calculated estimations (Booysen 2013). Figure 12.8 (image on right) shows ash plume and our visualization of the wave propagation. The plume height is relevant with respect to whether the Hebrews could have seen the plume from the Egyptian coast. According to Booysen, the 36-km ash plume height, estimated to be the possible height of Thera's ash plume, could not have been seen by the Hebrews considering the distance and the curvature of the Earth. However, Booysen estimated that the top of the Thera plume could

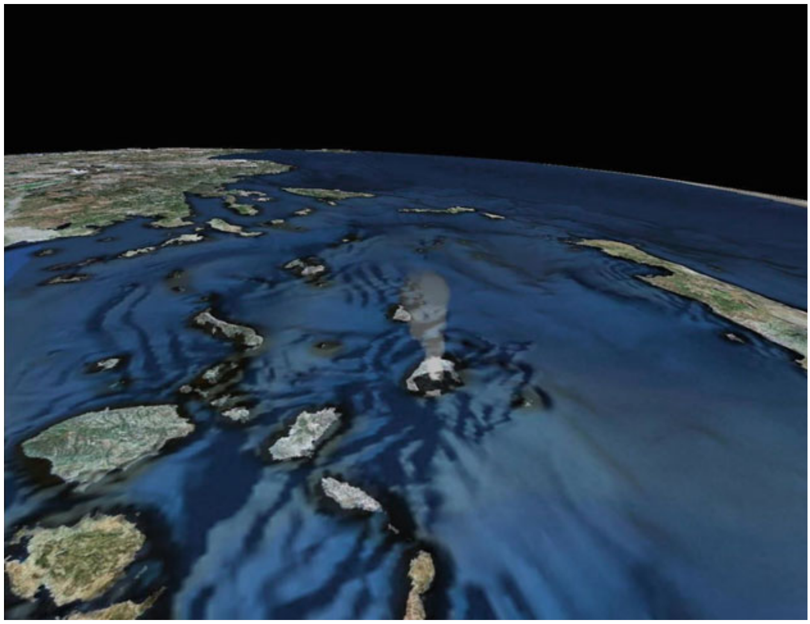

Fig. 12.8 Eruption of volcano on Santorini island with ash plume displayed in osgEarth

have reached approximately 58 km altitude if 100 km^3 of magma had been ejected. The authors of this chapter performed their own calculation to determine minimum height of the plume to be visible at the Nile Delta. The radius of the earth between Thera and Tel el-Dab'a (at midpoint latitude 33.6° N) is 6,372 km (rather than the equatorial radius of 6,378 km). The geocentric angle between Thera and Tell el-Dab'a is then 7.75° (1° is 69 statute miles = 60 nautical miles). Standard refraction effectively reduces this angle by about 0.57° to about 7.18°. This is approximately the angle below the horizon of the surface at Thera from Tell el-Dab'a. Using these corrections, we calculated the required height of the ash plume to be seen at Tell el-Dab'a to be $([1/\cos 7.18°] - 1)(6{,}372 \text{ km}) \approx 50$ km. Booysen cites the maximum possible plume height of a terrestrial volcano to be approximately 55 km. Therefore, it might have been possible for this eruption to be seen during the Hebrews' escape. The visualization of this data in the WAVE helped define and illustrate this debate.

Fluid dynamics simulations of a volcanically induced tsunami were provided by Steven Ward. 1,474 × 840 point ASCII Grid files were provided for each time step of the simulation, which were imported to ArcMap. Experiments were performed to determine the best way to import and process each file into an animation along the sea surface in osgEarth. We wrote a script to convert each ASCII Grid file to a 2,948 × 1,680 RGBA GeoTIFF file, with wave height mapped to a color gradient from light to dark blue, and a translucent alpha channel, so that the sea floor would be visible through the wave texture. Then each GeoTIFF was georectified in ArcMap using manually selected control points using the topography as the guide. Once each GeoTIFF was warped to fit the Earth surface by tessellating it into a mesh of 24 × 13 rectangles, a script was written to turn the 240 time steps into an animation, which represented a 4-h simulation time frame. Each time step was compressed using OpenSceneGraph's native binary compression into a 20 MB file, so that the animation occupied a total of 4.8 GB on disk. During rendering, multiple CPU threads were created to allow for a smooth rendering experience by asynchronously loading and buffering textures.

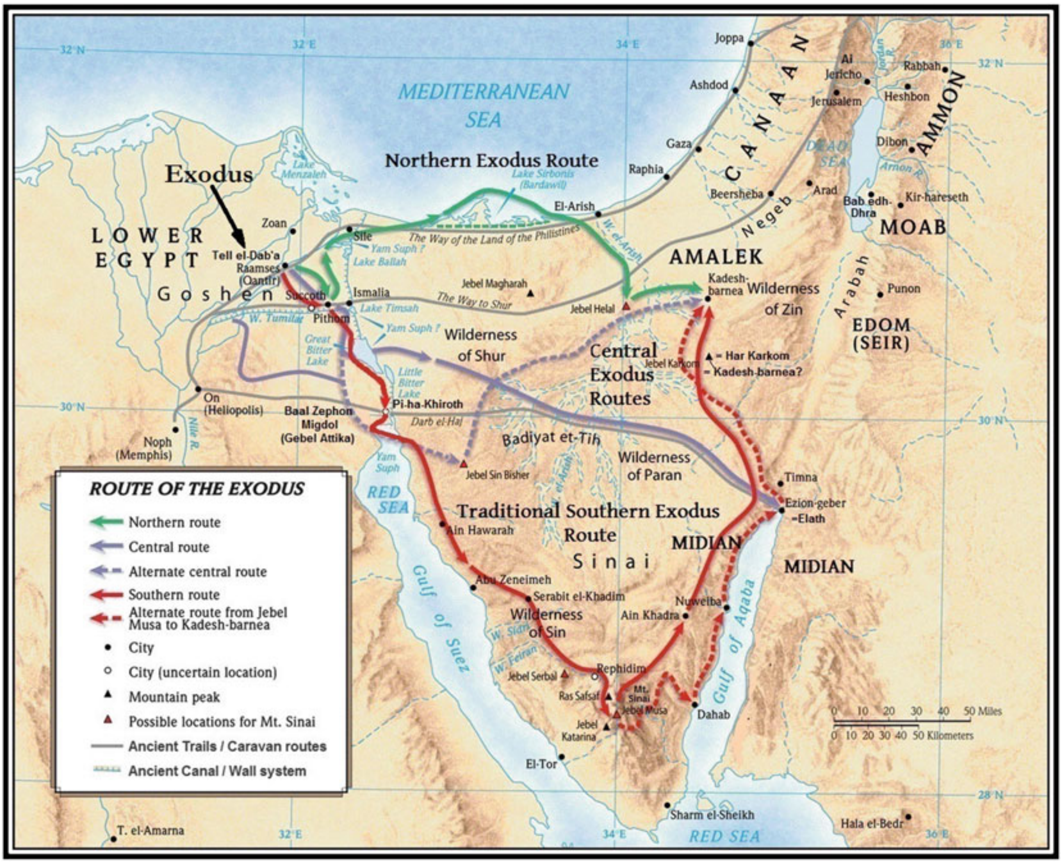

Fig. 12.9 Northern, Central, and Southern proposed Exodus routes (Ellis Smith 1993, as modified). (***Note: Route lines are in schematic outline only, not exact trail routes.***) Modern coastline is shown. See Fig. 12.10 below, and Chap. 9, Fig. 9.3b, for reconstruction of ancient coastline of the Nile Delta, ca. 2000–1000 BCE

Archaeological and Theological Data: Travel Routes

There are three main Exodus routes presented by which the Hebrews are argued to have escaped Egypt to Israel, see Figs. 12.9 and 12.10.

Moshier (Moshier and El-Kalani 2008), Bietak (Bietak 1996) and Stanley (Stanley and Warne 1993a) provide geomorphic and archaeological evidence for a northernmost route of the Exodus, also supported by archaeological evidence for the Biblical place names, such as *Yam Suph* (sometimes translated "Sea of Reeds" from the Hebrew), suggesting that the crossing of the Sea occurred in the salt marshes and shallow lakes between the Mediterranean and Red Seas (Fig. 12.9). The central route is based on the covenant experienced in Exodus 19:16–25 and also goes through the home of the Midianites, where Moses married his wife, Zipporah. The southern route is traditionally supported as the Exodus route placing Mount Sinai in the southern Sinai Peninsula. This route has been supported by the identification of *Yam Suph* as the "Red Sea" in the Greek Septuagint (a geographic site *identification*, not a Hebrew-to-Greek language *mistranslation*) (arguing for "Reed Sea" and claiming "Red Sea" is a mistranslation: Kitchen 2003: 261–3; Hoffmeier 2005: 81–85, 163–4; Hoffmeier 1999: 199–222; refuted by Batto, this volume, by Propp 2006: 752, Houtman 1993: I:128, Vervenne 1995: 424, et al.). The routes described above were georectified in ArcMap in order to digitize the paths of these Exodus routes into line shapefiles, and then translated into 3D tubes in osgEarth. It was necessary to draw

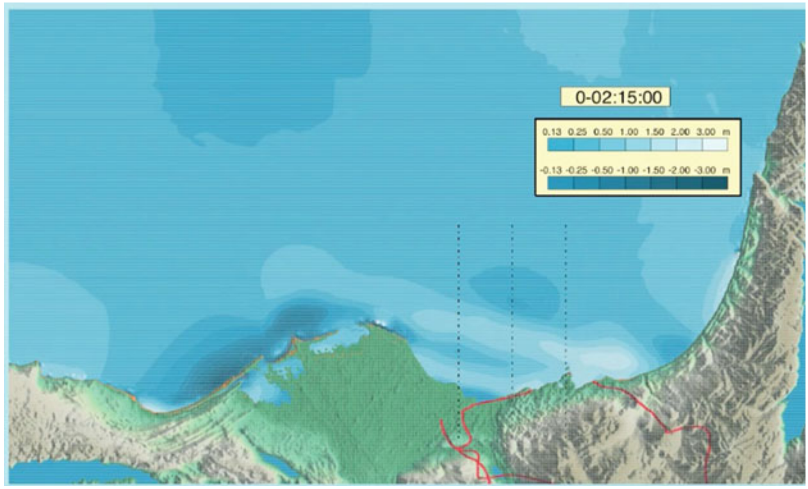

Fig. 12.10 Approaching tsunami wave along ancient coastline showing northern Exodus route affected by the oncoming wave (model by Steven Ward)

tubes instead of vectorized lines to make the travel routes more easily visible, and to be able to shade them to look properly three-dimensional. The travel paths were positioned 250 m above ground, so that we could avoid intersections with the ground.

Archaeological Data: Egyptian Forts

Bietak and Hoffmeier have excavated Egyptian forts in the northeastern Delta near the coast of the Sinai Peninsula that may be alluded to in Biblical texts (see also Moshier and Hoffmeier, Chap. 8). Due to the relevance of these locations to influence on the possible Exodus paths, the point locations were represented on the osgEarth using colored spheres with place names as labels. Key locations include Pi-Ramesses, Tell el-Dab'a (Avaris), Kadesh Barnea, Aqaba, and Jebel Musa. Because each of these landmarks provides evidence for different Exodus routes, we triggered each location to appear on the Earth when they were relevant to the narrated story, as it was told. The eight total site markers were imported to osgEarth as point shapefiles, similarly to the routes, and rendered as 3D spheres, hovering above the regional terrain. They vary in color and size depending on their relevance.

Telling the Story: The Demonstration Application

Merely fusing all of the above data into one large map would not have effectively told the fascinating story of the latest research results about the Exodus. We wanted the visitor experience to be such that the visitors could stand in front of the WAVE and watch the story unfold. We designed an automated flight path through the areas of interest to synchronize with a scripted narration written by UCSD archaeologist Prof. Thomas Levy. The script was written to concisely describe and view all of the data elements in this chapter in order to present the viewer with scientific evidence for the relationship between the Theran eruption and the Exodus of the Hebrews. Once the script was written, it was narrated by Tiffany Fox, one of our Institute's voiceover experts. We ended up with 12 separate parts of the narration, which we stored as separate audio clips on disk.

Using the timeline of the script, we experimented with ways to best choreograph the flight path to match the story. We tested flight speeds to approach the relevant regions synchronized with the narration. Knowing that the narration tries to convey the relevance of the regional geography, we took care to create the flight path from an oblique bird's eye view, minimizing turning motions to prevent motion sickness of the audience. Although the WAVE was designed as an immersive environment, zooming down to the ground level would have defeated the purpose of merging Mediterranean region-level data. We maintained regional views while focusing on key elements throughout the narration. The WAVE construction supported this nicely in that you could take advantage of the lower curvature of the tile display to simulate flying over the earth.

We recorded the flight path with OSG's path recorder, which we integrated into CalVR within the osgPathRecorder plugin. When activated, it recorded position and orientation of the viewer for every rendered frame, along with a time stamp. At playback time, positions and orientations were interpolated based on the elapsed time, so that the path played back at the same pace as originally recorded, despite likely differences in frame rate.

We also recorded the time stamps to trigger the audio clips and when to display relevant data in the story. During playback, at the appropriate times during the narration, the CalVR plugin triggered the playback of the audio clips by sending the clip's ID number to our audio server via a custom TCP protocol. The same plugin also turned on and off the various data types, such as drill cores, travel routes, and fort names.

We instrumented the WAVE with a Kinect device, which senses the presence of a person in the WAVE. If someone was there, CalVR automatically started the flight path and synchronized the audio clip. This allowed us to keep the WAVE quiet when nobody was watching, so as to avoid unnecessary distraction of visitors of other parts of the exhibition.

Discussion

Overall, the high-resolution, wide field of view display system of the WAVE was a very effective platform for the 3D virtual globe platform, particularly the automated flight over the terrain. Visitors found the narration matched with the automated flight path to be intuitive and insightful to follow in the fusion of data types for the telling of the story. These datasets had never been seen together before, and the product of this effort is exemplary interdisciplinary collaboration and research. Insights to where, when, and how the Late Bronze Age environment could have influenced the story of the Exodus has been revealed to researchers and lay audiences alike.

This paper describes an experiment in combining temporal geospatial data, prototyped on a hardware system that was built only days before exhibition opening. During development, the disparate data formats and sources posed challenges for the amount of work required to reduce data sizes to balance rendering ability and the required level of detail. Much time-consuming trial and error was necessary to converge on an overall real-time rendering rate. A compounding factor was that the WAVE was not available for testing until a few days before the Exodus exhibit opened, so we had to test on comparable, but not identical systems. Hence, some of the final tweaking had to happen in the days and hours before show time.

Other challenges were found when blending data across multiple software platforms. To solve this problem, the team collaborated to optimize functionality among the software available. This issue is particularly evident when converting geospatial data from a traditional 2D desktop application to a 3D environment. 3D geospatial visualization does not display vector data easily. In order to look good in a 3D environment, points must be represented as 3D objects, lines must be represented as tubes, and areas represented as rasters, thus increasing the volume of data to be rendered. By taking advantage of the new WAVE 3D immersive environment, and integrating it with the sonic arts (Seldess et al., Chap. 11) and MediaCommons Framework, we have been able to build the world of the Exodus in a meaningful way for twenty-first century audiences.

Conclusion

For the first time, ancient world building applied to the Hebrew Exodus from Egypt was taken to an immersive level by employing the new 3D WAVE experience. We successfully used CalVR, ArcGIS, GDAL, OpenSceneGraph, and other software tools to create a real-time rendered 3D demonstration of a possible scenario for the Parting of the Sea in the story of the Exodus. While we built the application on top of existing components, a large amount of custom work was necessary to bring all the pieces together seamlessly. In the future, it would be desirable that authoring tools be developed to simplify and streamline the many aspects of this project. But we were able to show that for an experienced team of content creators and programmers it is possible to pull together a complex 3D application in the relatively short time frame of about 2 months.

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