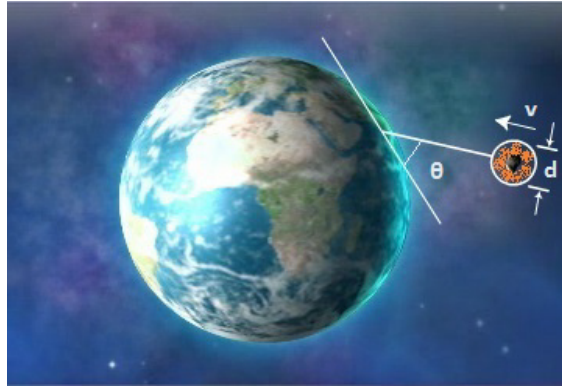


Impact Scenarios in the Classroom



1. Introductory phase and preparation

Introduction

Impact Scenarios in the classroom is an activity performed during the **astronomy school** which is annually organized by the Astronomy and Space Society of Volos. It is based on inquiry learning principles and on an interdisciplinary approach of the subject of meteorite impacts on earth. The primary goal is to fit the **down2earth model** (http://education.down2earth.eu/impact_calculator) output data to existing **geographical and geological information** concerning two lakes in Magnesia (Central Greece) which it is suspected to be the product of a meteoric collision in the past. In the final stages of the activity conclusions are drawn on **the trajectory and dimensions** of the meteorite itself and an attempt is made to predict, via the model output, **the devastation effect** of such an impact in two nearby towns, if the event was taking place today.

1.1 Guidance for preparation

The activity is assigned as a project work to a group of two or three students (age: 15-18) in the beginning of the class after a brief presentation of the subject in the classroom which also includes some video watch from you-tube.

2. Teaching Phase 1: Question Eliciting Activities

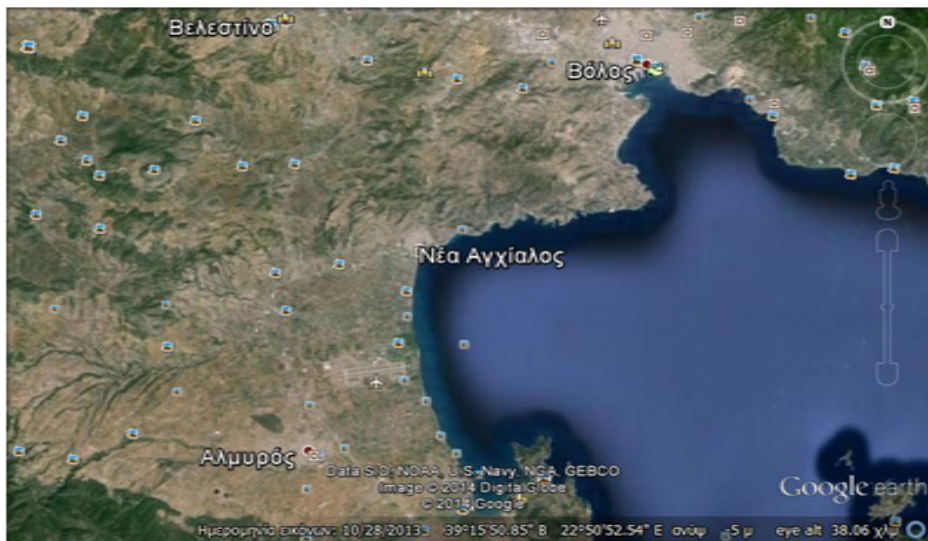
2.1 Provoke curiosity

Watch in you-tube videos of Chelyabinsk Meteor in 13 Feb 2013

Watch in you-tube other relevant videos

2.2 Define questions from current knowledge

The students are asked to investigate the geographical features at 39.16 N and 22.71 E by using the google earth software. The place is close to “Αλμυρός” town (as depicted in the following pictures).



- a. What is the origin of the twin Zerelia lakes?
- b. Has the Prehistoric settlement, seen between the lakes, any connection with the impact event?
- c. Why there are no substantial deviations from circular shapes?
- d. Are they the product of one or two meteorite impacts?
- e. What was the diameter of the Projectile(s) that produced them?

3. Teaching Phase 2: Active Investigation

3.1 Propose preliminary explanations or hypotheses

- a. We suspect that the twin lakes are the product of meteorite impact(s) and investigate existing bibliography.
- b. Prehistoric settlement is probably not chronologically related to them but it needs further investigation.
- c. Circular shapes are attributed to the explosive nature of a meteorite impact.
- d. Two craters correspond to two projectile fragments probably at the same time in the past. (The occurrence probability of a meteorite impact at the same place has to be considered)
- e. The diameter of the projectile that produced them must be less or equal in size to the lake diameters and the crater depth must be close to estimated depth taking into account also the water depth and the sedimentation process.

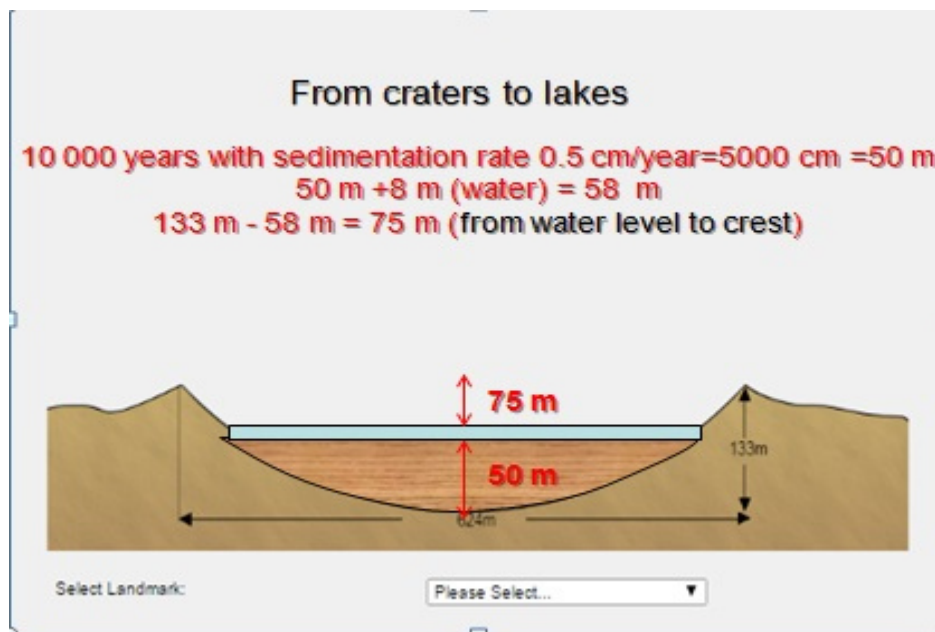
3.2. Plan and conduct investigation

3.2.1. Geological investigation

A visit to the lake territory permits students to estimate the crater depth (i.e. using bus height)



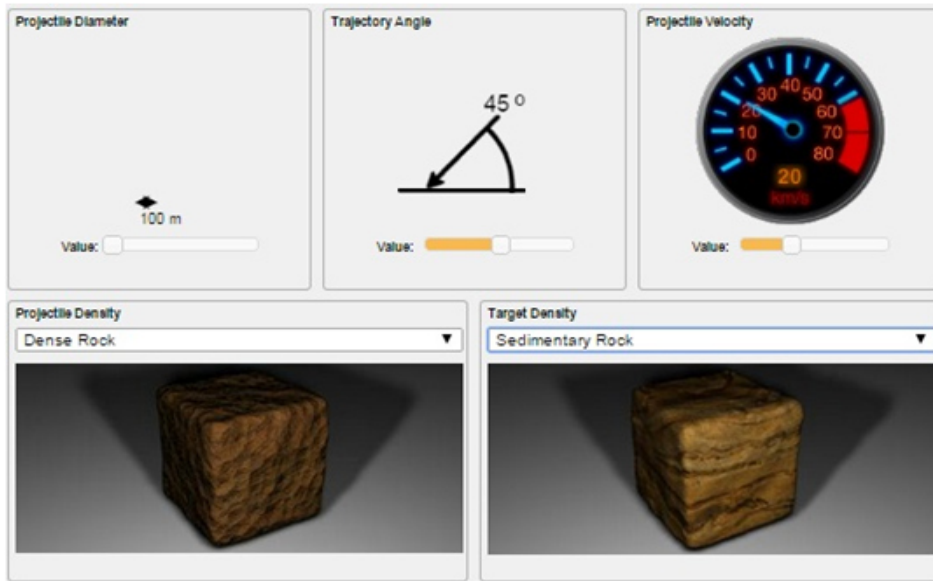
Bibliography offers some values for the time of the impact event, the sedimentation rate in the area and the lake water depth.



3.2.2. Astronomical investigation

Students decide to use dense rock for the projectile material because no iron core or fragments are discovered.

They are also guided to use sedimentary rock for the target material.



- Run the down-to-earth model (above picture) introducing 7 different projectile velocity values (10, 20, 30, 40, 50, 60) at constant **trajectory angle 45°**
- Do the same for projectile **velocity = 20km/s** (most frequent value in bibliography) and trajectory angle values (10, 20, 30, 40, 50, 60, 70°)
- Select the most appropriate scenario that fits geological evidence (i.e.)

Predicted crater diameter less than (250+150 m),

Predicted crater depth ~130 m,

Predicted fragmentation of the projectile

4. Teaching Phase 3: Creation

Calculation Results - Crater Size

Parameter	Value
Crater Depth	133 m
Crater Width	624 m
Burst Altitude	2,274 m
Break-up Altitude	56,644 m
Wind Velocity	572 m/s
Richter Magnitude	0
Sound pulse amplitude	116 dB

Please Select...
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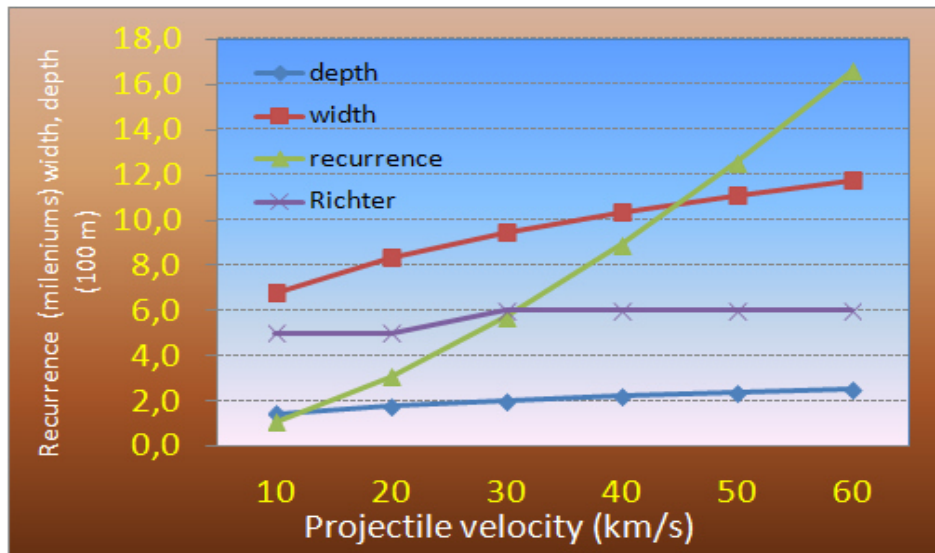
Click the map to place the crater...

Go Back Crater Size Crater Depth Data View

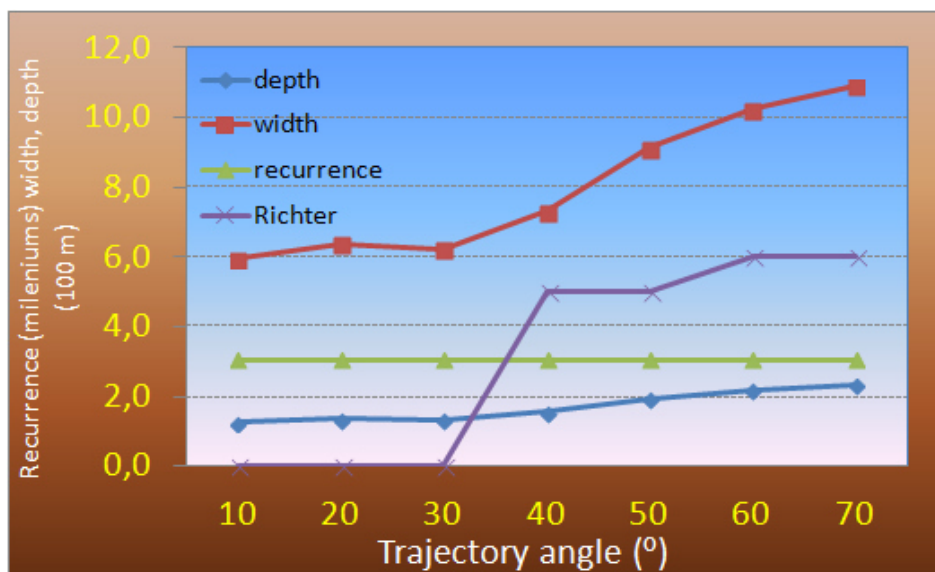
4.1 Gather evidence from calculation

The students create data tables and plot the values creating diagrams like the following.

(a)



(b)



From (a) diagram only 10 or 20 Km/s produce a crater with a depth less than 200 m

From (b) diagram the most appropriate value is 30 degrees. A 30 degrees value results in 130 m depth and a diameter about 600 m (sum of the two lake diameters)

They have to keep in mind that lower limit of model's value for projectile diameter is 100 m

5. Teaching Phase 4: Discussion

5.1 Consider other explanations

There is no geological evidence for volcanic activity in the area. Therefore, crater formations have to be attributed to other reasons.

5.2 Explanation based on evidence

- It seems that (a) hypothesis (meteorite origin) is the most appropriate.
- The prehistoric settlement was, according to museum specialists, established 6000 years ago, while the impact took place, according to geological evidence between 8000 and 12000 years ago. Humans were attracted by the water source and the wild life related to the lakes (migratory birds)
- The impact blast must be responsible for the circular shapes.
- The twin lakes are probably the product of a single meteorite that was separated in two pieces (in agreement with model output data) at 2.5 km above surface.
- The diameter of the projectile (meteorite) that produced the lakes was less than 100 m and was divided in two almost equal (63% - 37%) pieces.

6. Teaching Phase 5: Follow up

Visit Archeological Museum of Almyros to see the evidence on prehistoric settlement



Visit Zerelia Lakes



6.1 Communicate explanation

Produce a slide show from the visit

7. Other

7.1 Prediction

a. Based on the finally selected impact parameters ($v=20$ km/s and $\text{angle}=30^\circ$) what would be the sensation of the impact in Almyros town (Αλμυρός is located 6 km from the lakes) and in Volos city (Βόλος is located 30 km from the lakes) if the event was taking place in our days;

The following picture (from an F4 tornado outbreak in USA) selected by the students represents what is the model's prediction for Almyros town



The next picture which is also selected by the students (comes from Chelyabinsk) depicts according to the model what is expected for Volos city



b. What would have happened in Volos city if the same meteorite was hitting the surface of the gulf.



Output from a different model which predicts Tsunami waves from impacts on the ocean (<http://www.killerasteroids.org/interactives/impact/impactCalc1024.html>)



A 21 m Tsunami is expected as a rough estimation and the above figure depicts the flood up to 21 m height contour in Volos city.

It was also created by the students with the help of google earth