Safe Navigation with an Open Sea Chart

Bernhard R. Fischer

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whoami

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- Contributor to Open Source Projects

Agenda

- Surveying and its history
- Charts in general
- Sea Charts
- Lights and Depths
- Security Issues

DO NOT USE FOR NAVIGATION

Why creating a free sea chart ?

→ Drop the project or

make it high quality !

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Sources for Navigational Important Information

- sea charts
- List of lights
- hand books of harbors and coast lines
- list of radio stations
- tide tables
- astronomic almanacs
- notices to mariners

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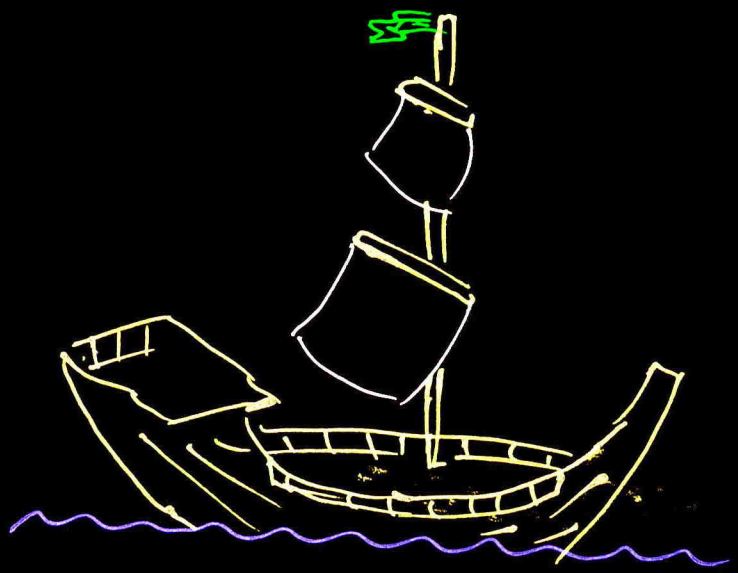
Famous Explorers



Henry the Navigator
1394 – 1460

Christopher Columbus
1451 – 1506

Vasco da Gama
1460 – 1524

Ferdinand Magellan
1480 – 1521

James Cook
1728 – 1779

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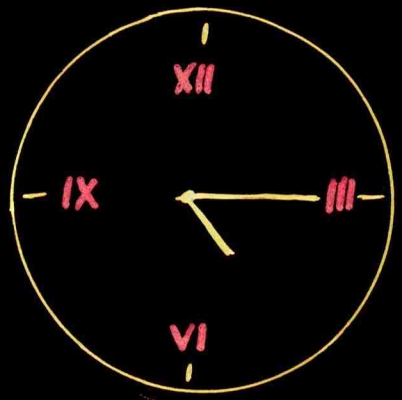
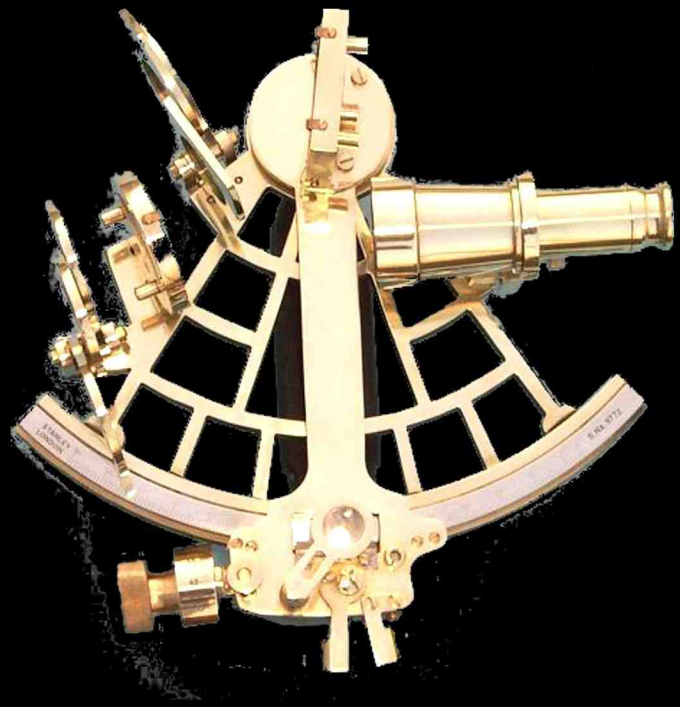
Methods of Measurement

- Astronavigation
- Measurment of Time
- Trigonometrical Survey
- Figure of the Earth





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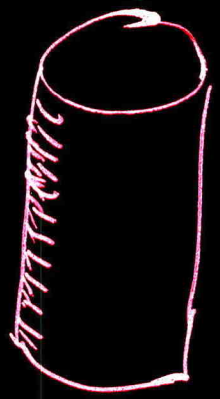
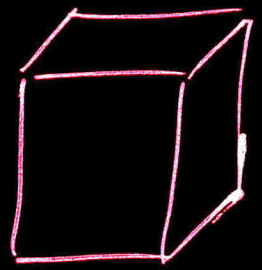
Ancient Greek Philosophers suggested ...



cylindrical



cubic

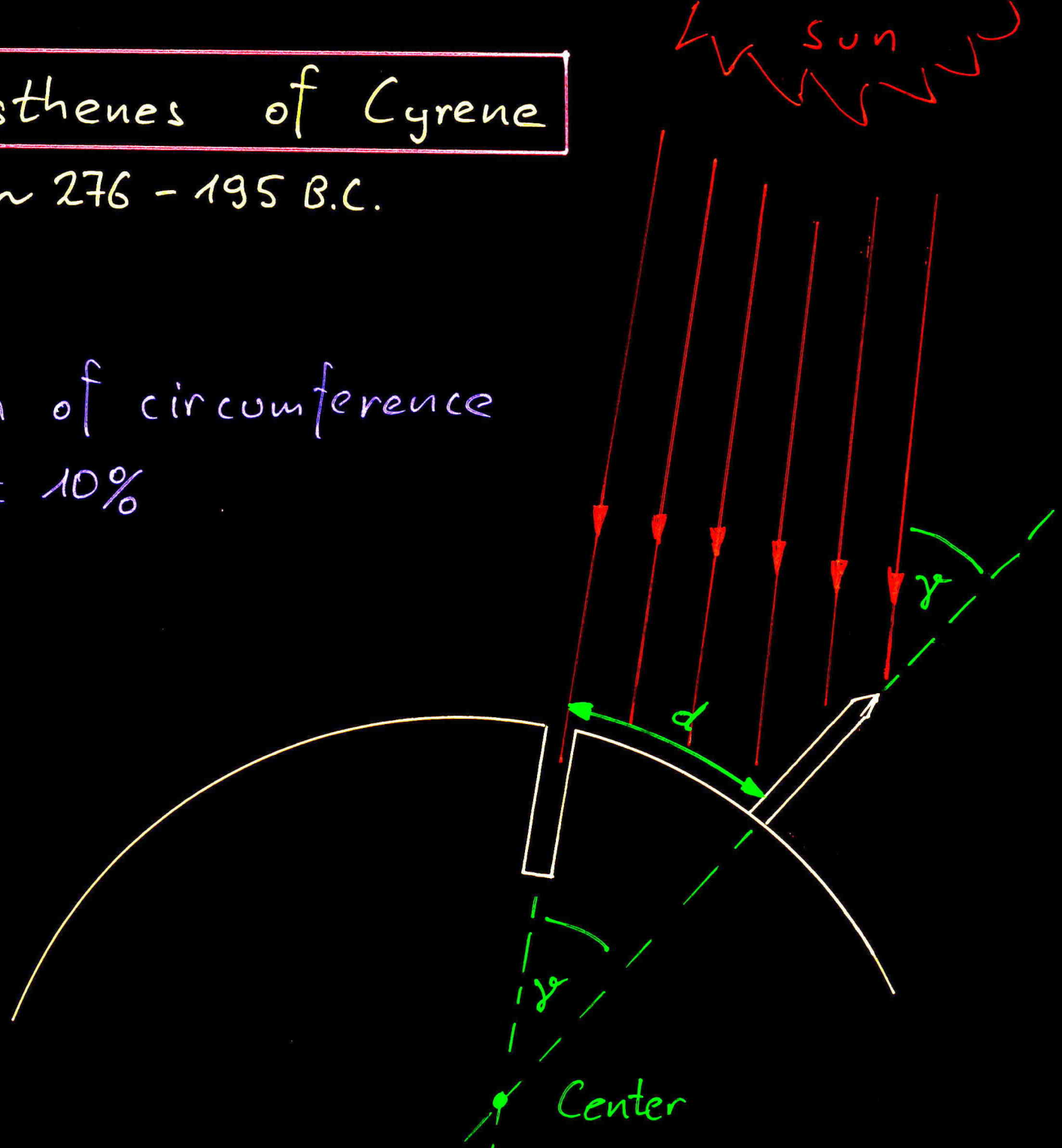
spherical

Eratosthenes of Cyrene

~ 276 - 195 B.C.

Estimation of circumference

to ± 10%



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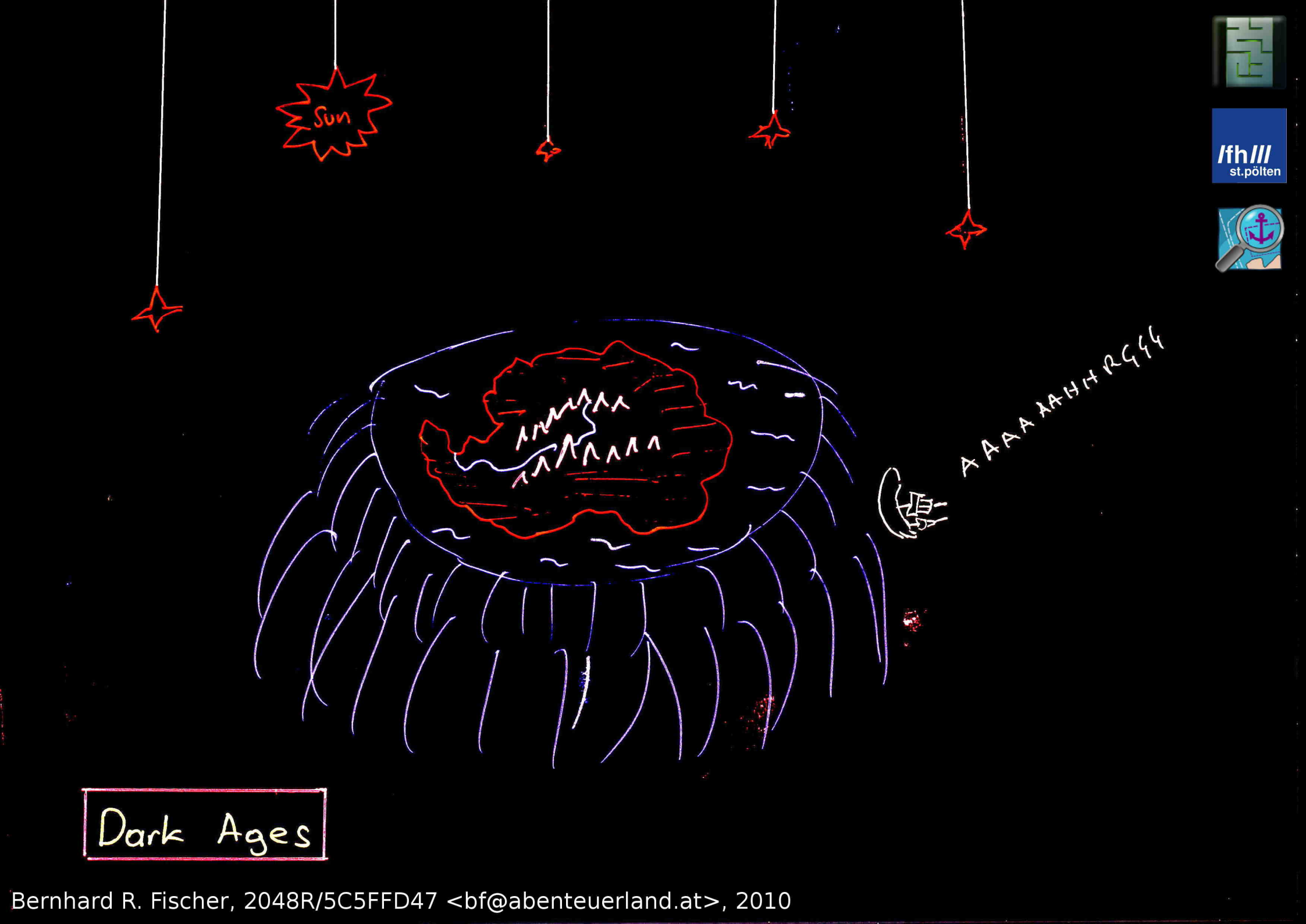

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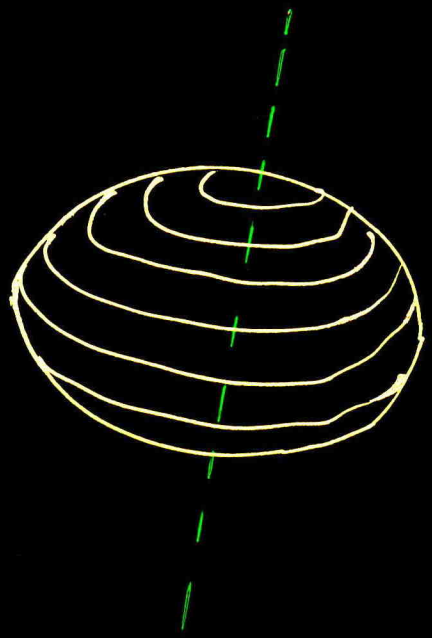
Spherical body raises some oddities ...

Christian Huygens (1629 – 1695)

Isaac Newton (1643 – 1729)



The Ellipsoid of Revolution

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It became even worse ...

True Figure of Earth

Carl Friedrich Gauss
(1777 – 1855)

True figure expresseol by surface of equal gravitation.

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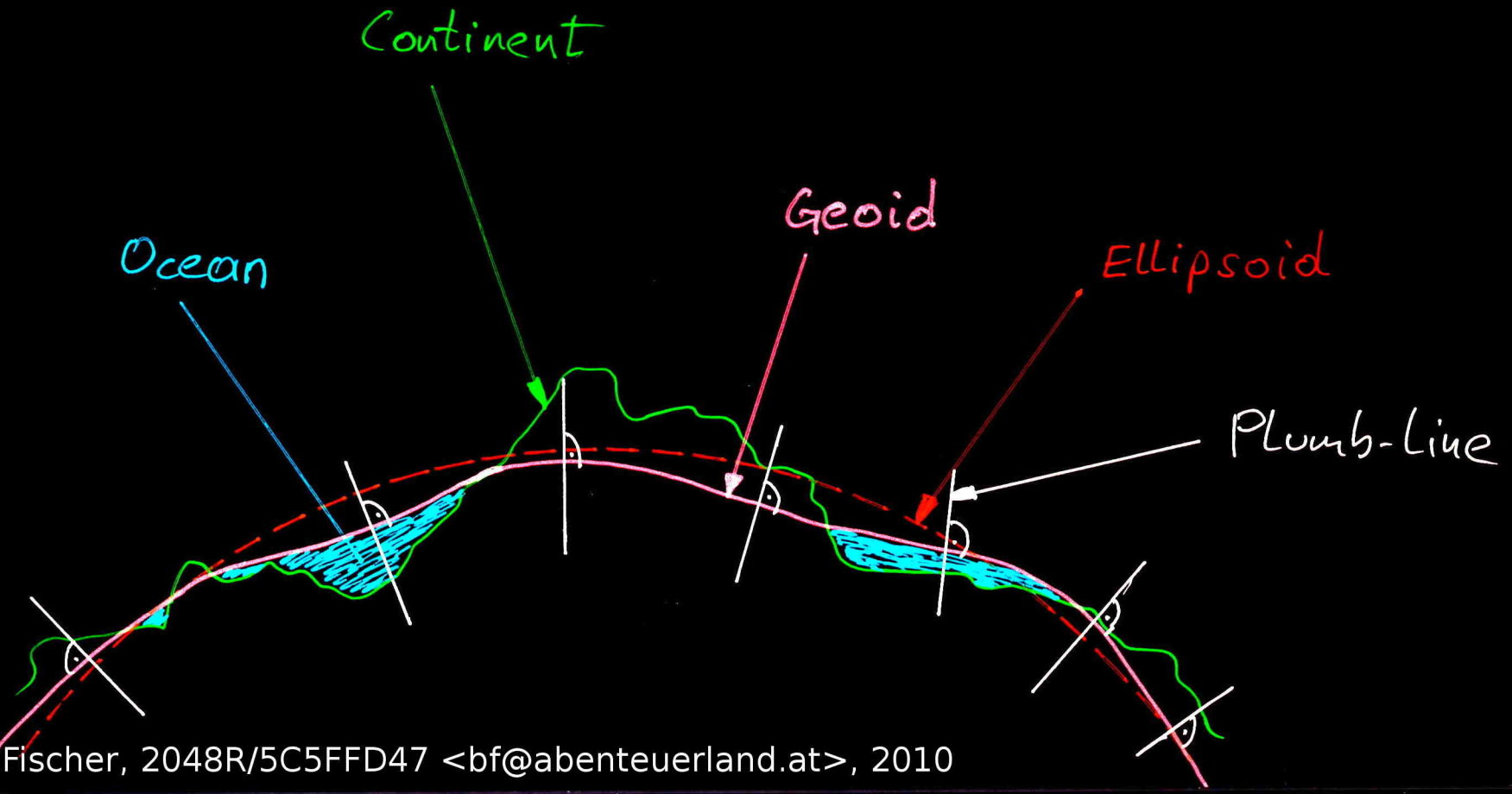
The Geoid

Surface of equal gravitation → mean surface of oceans in an equilibrium.



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Reference Ellipsoid

- Geoid has irregular surface.
- Reference ellipsoids are mathematical expressed.
- Various reference ellipsoids exist:
  - Bessel ellipsoid, 1841
  - Kraskowsky ellipsoid, 1940
  - Hayford ellipsoid, 1924

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World Geodetic System 1984

defines a reference ellipsoid
and Earth Gravitational Model 1996
and reference points.

→ Geodetic Datum

Coordinates referring to object

→ Coordinate Reference System

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Geographic Coordinates

are based on coordinate reference system

Latitude φ

Longitude λ

φ: $\pm$ 90° from equator

λ: $\pm$ 180° from prime meridian

+ → north and east , − → south and west

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Elevation

All positions have 3 dimensions

φ, λ → reference ellipsoid

elevation → geoid

ref. ellipsoid of WGS 84 differs from EGM 96

$\pm$ 100 meters

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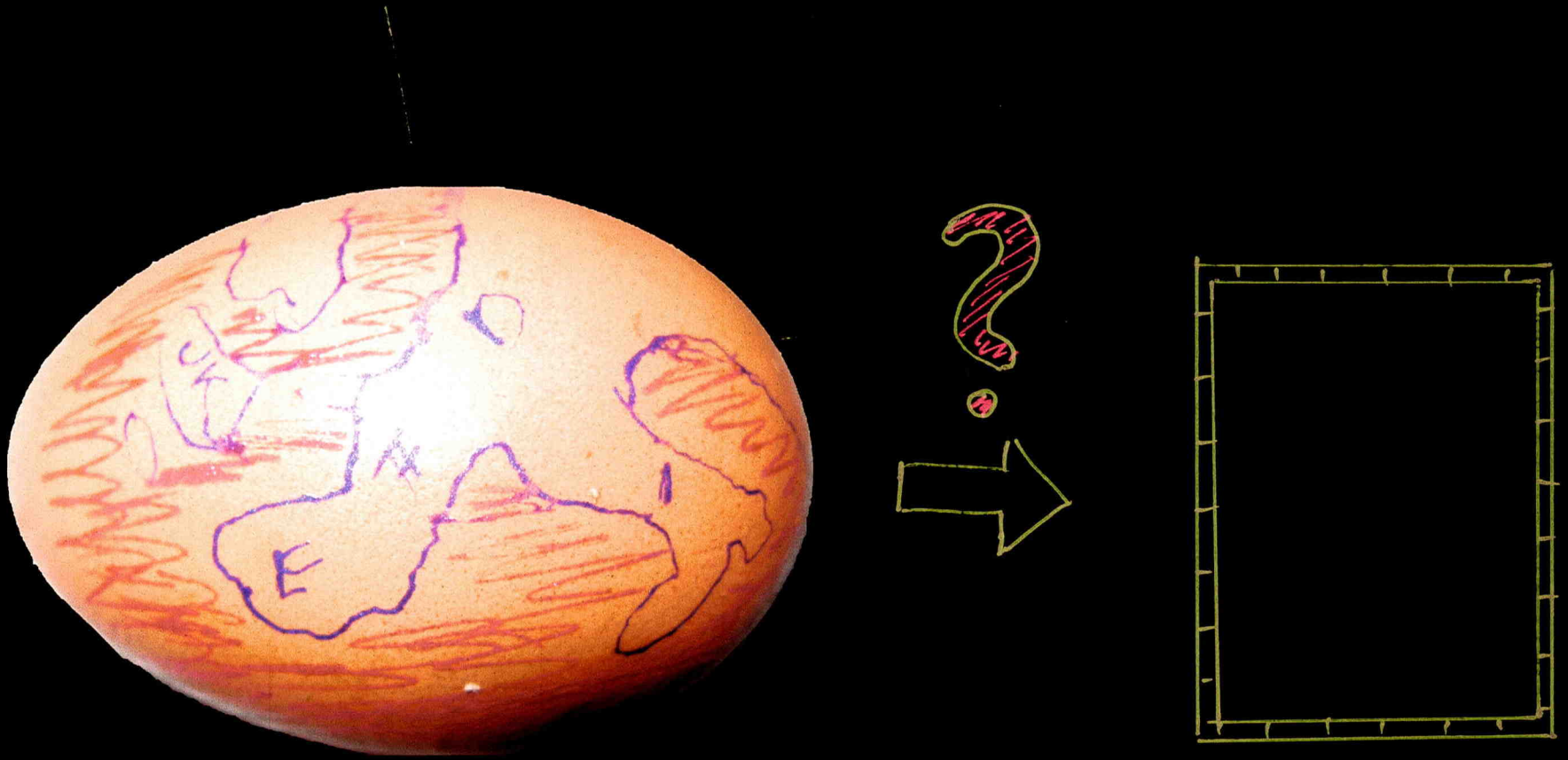
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Map Projections

Several methods available

Sea charts → Mercator[1] Projection

- preserves angles and distances in small scales

1 Gerardus Mercator, 1512–1594

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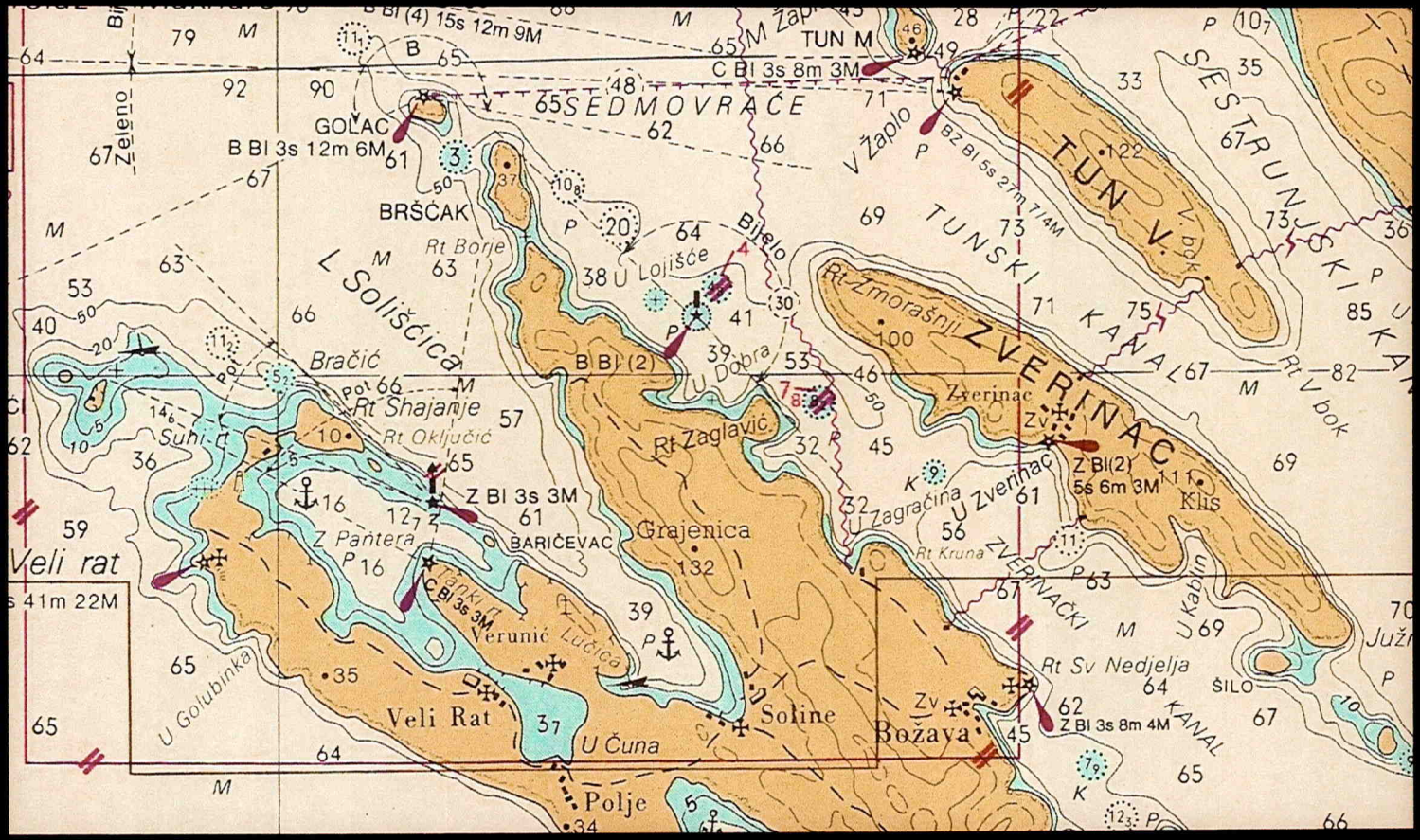
About Sea Charts

1:100 000 !



... contains a lot of vital information.

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Road Maps vs. Sea Charts

- Nav. of vessels not limited to roads.
- Underwater obstructions invisible.
- No road signs.
- Vessels can't just stop and ask for way
- Harbor approaches might be time consuming

Chart accuracy is a MUST!

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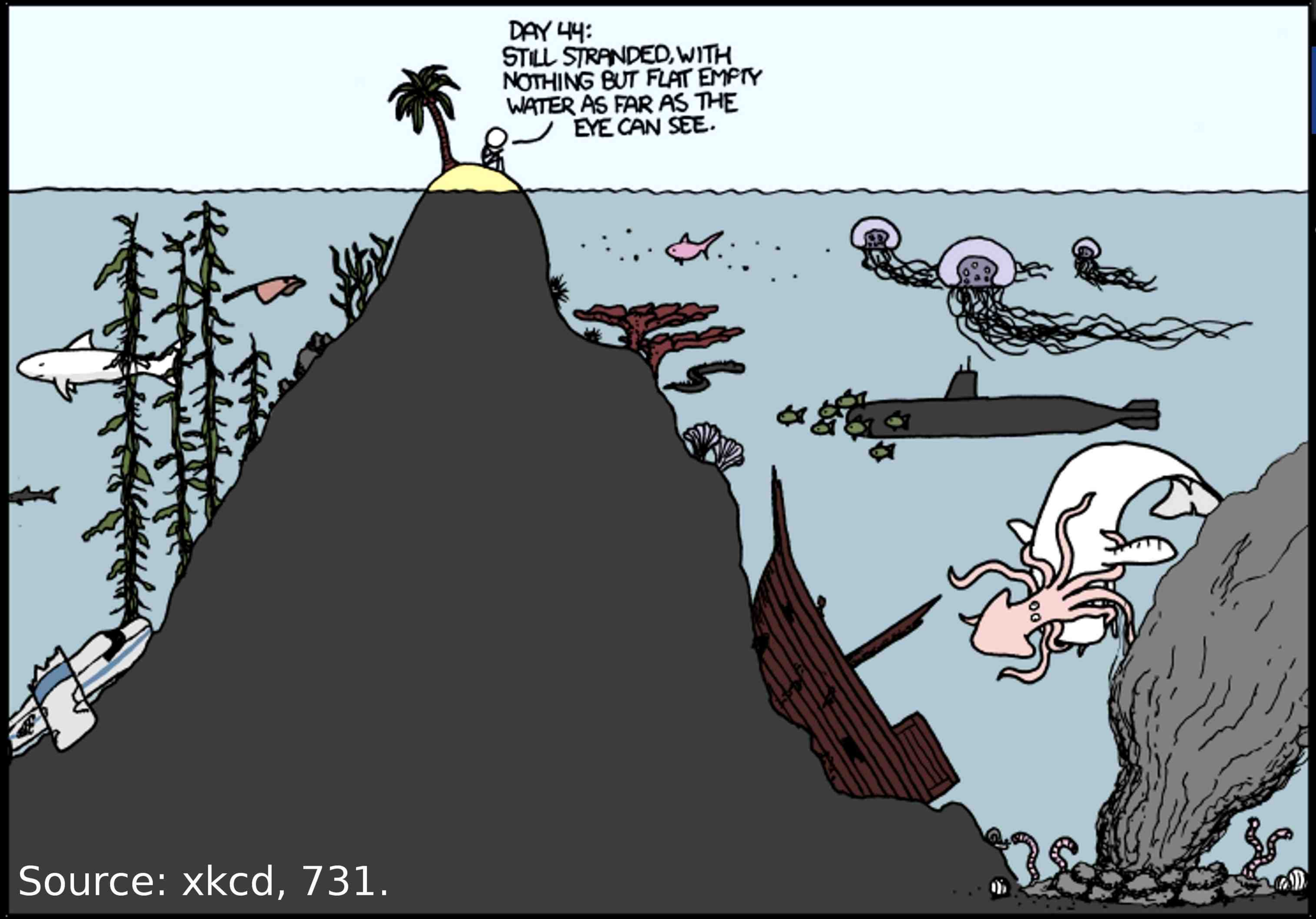

Source: xkcd, 731.

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National Reference Systems

... are used in official charts.

E.g. Croatian differs from WGS 84

0.28' E, 0.01' N → 370 meters

Creating Free Sea Charts

- Official Sea Charts[1] → ©
- and it is interresting and fun.

- Chart accuracy is a big challenge.

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1 official charts may contain errors.

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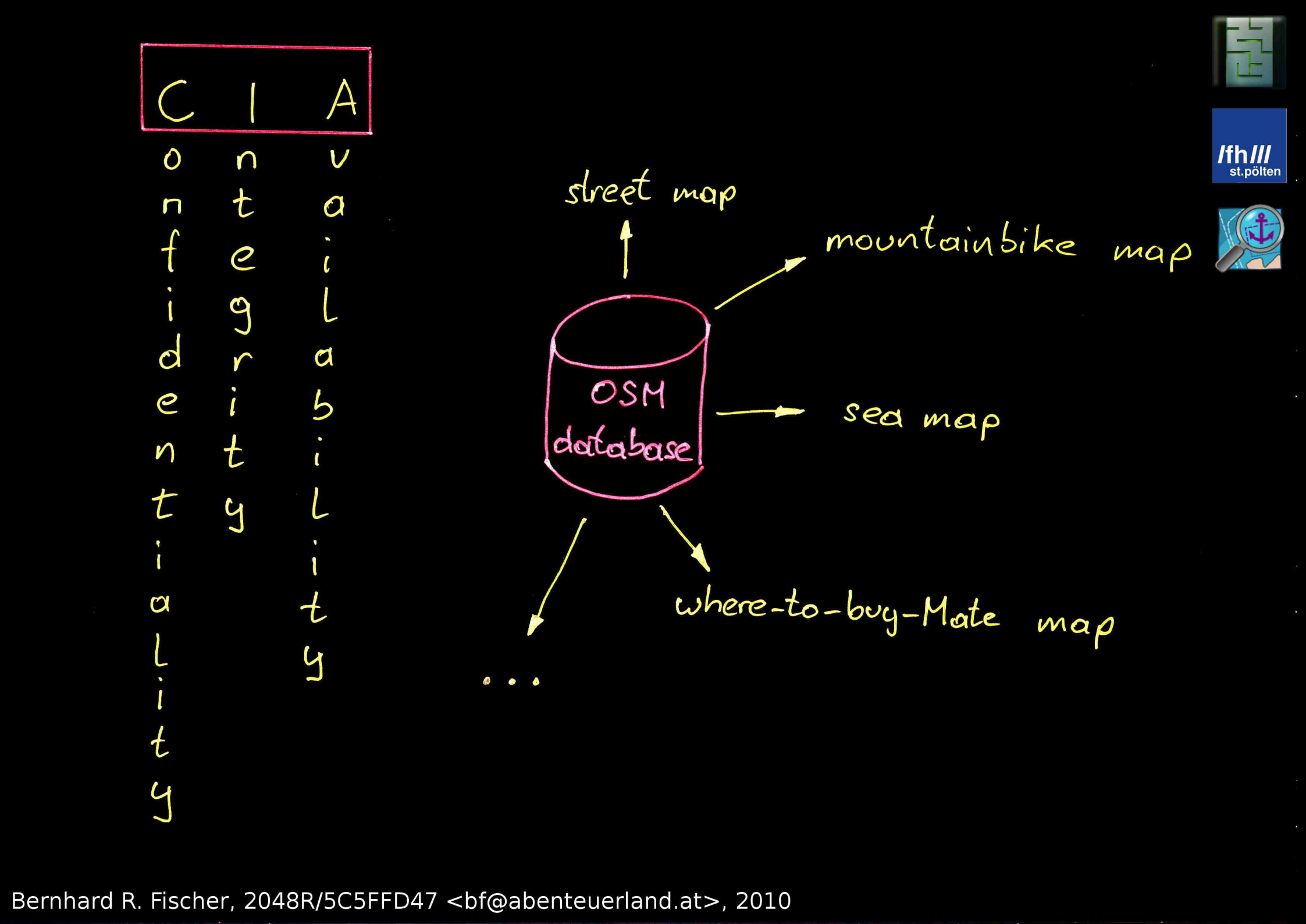

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THEY

watch us
monitor us
control us
limit our freedom
gather our information

and WE try to protect from THEM

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Open Street Map

database is open to everybody.

OpenSeamap might need

more stringent trust model.

→ user credits

→ Web-of-trust model

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Gathering Information

- 
- People with GPS handhelds
- Other non-© sources
  - ↳ like the „List of Lights"

List of Lights

- PDF documents
- syntactic and semantical errors
- positions not highly accurate
  (approx. tenth of a minute)
- geographic coordinates may refer to
  national reference system != WGS84

PDF Data Extraction

```
if ( /(([0-9]{1,3}° ([0-9]{,2}\.[0-9]' ([NS]) (<b>([^<]*)<\/b>)(.*?)/
```

no → `/(0° 00.0')/`

yes → `/( )or( )(<b>(.*?)<\/b>)(.*)/`

`/(0° 00.0')/`: yes → `/( )or( )(<b>(.*?)<\/b>)(.*)/`; no → `detection_error();`

`/( )or( )(<b>(.*?)<\/b>)(.*)/`: no → `vert_position();`; yes → `alternate_character()`

`vert_position();` → `no_latitude();`

```
elsif (/^(([0-9]+)(\.[0-9]+)?) (\-?(<(.)>|([A-z"]))|-)([^<]*?)(\.)
```

`if $linecount < 3`: no → `if $previous_number < $7`; yes → `short_stanza();`

`if $previous_number < $7`: yes → `short_stanza();`; no → `short_stanza();`

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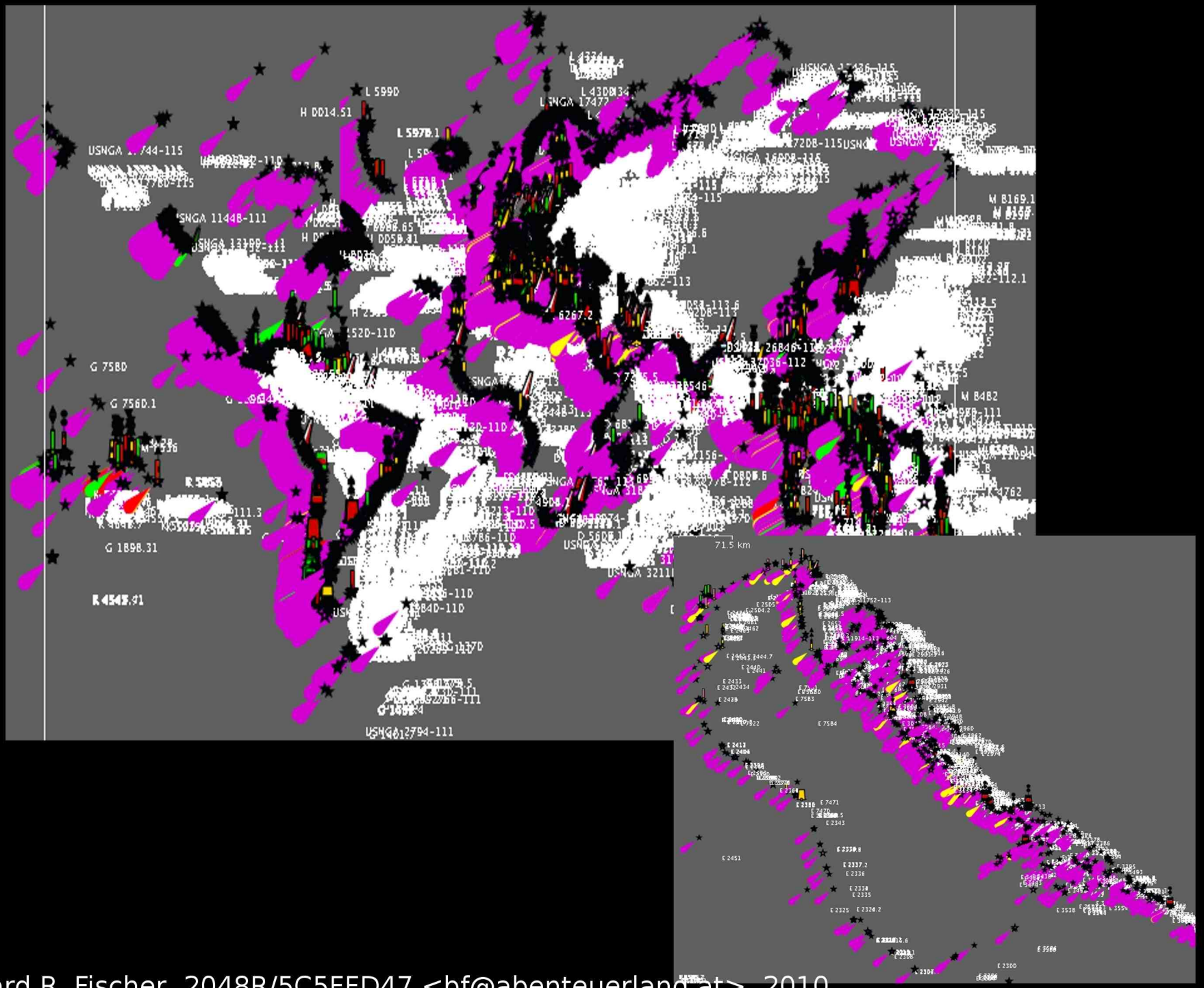
Extraction Result

- CSV, about 50 000 lights[1]
- approx. positions
- various reference systems

- automatic position correction seems impossible.
  - ↳ manual data enhancement necessarry

[1] OSM contains ≈ 2000 entries.



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Depths

- Accuracy requirement: ≤ 0,5 meters
- Surveying depths is NOT trivial!

- Ocean surface is in permanent movement:
  - winds
  - tides
  - currents
- Sea bed may change also.

Calculating Depths

- Time and Date
- Position
- Chart Datum
- Chart Depth

↳ shake this well together with tide tables

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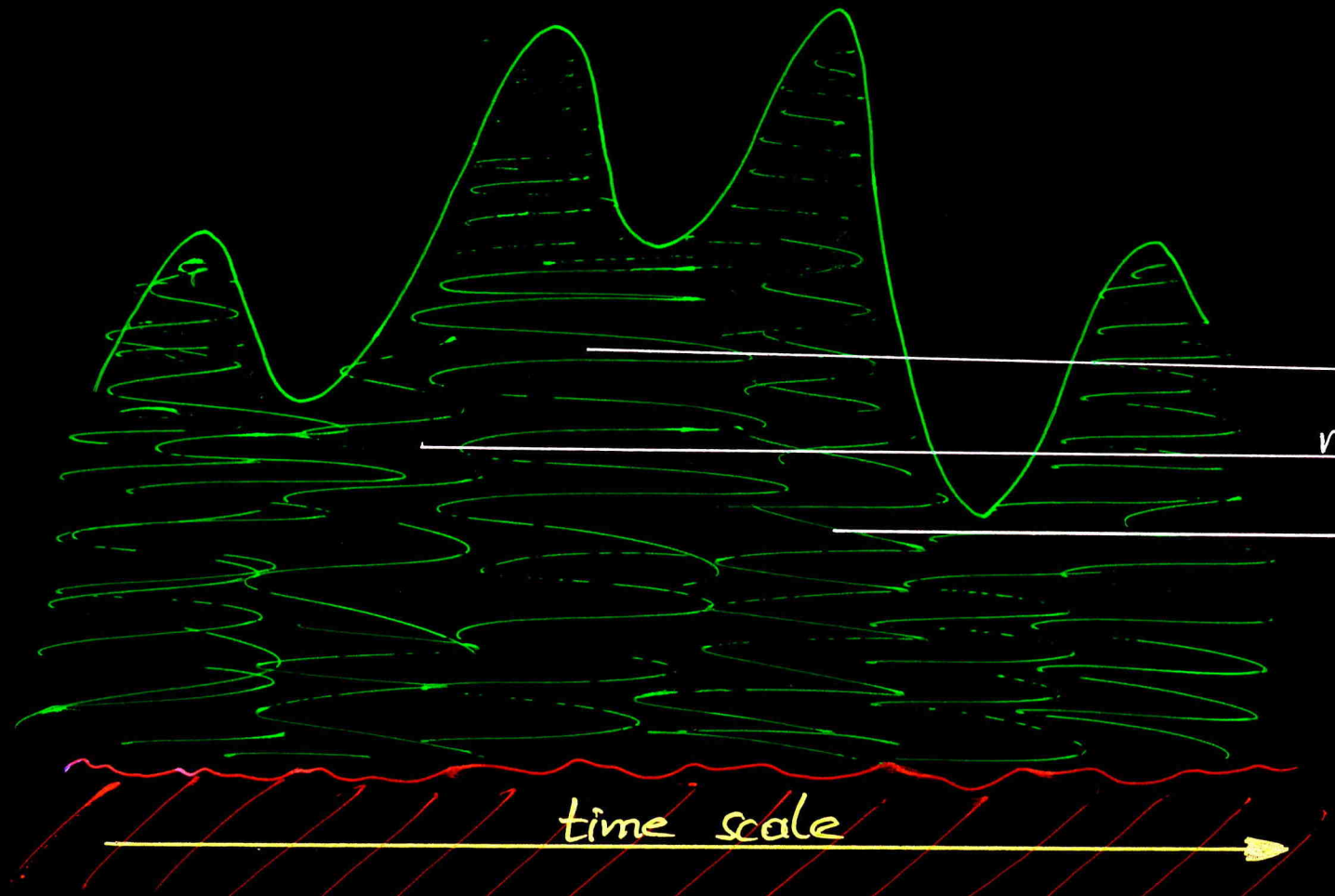
Chart Datum

- sea charts refer to virtual static sea level.



Where is the geoid surface?

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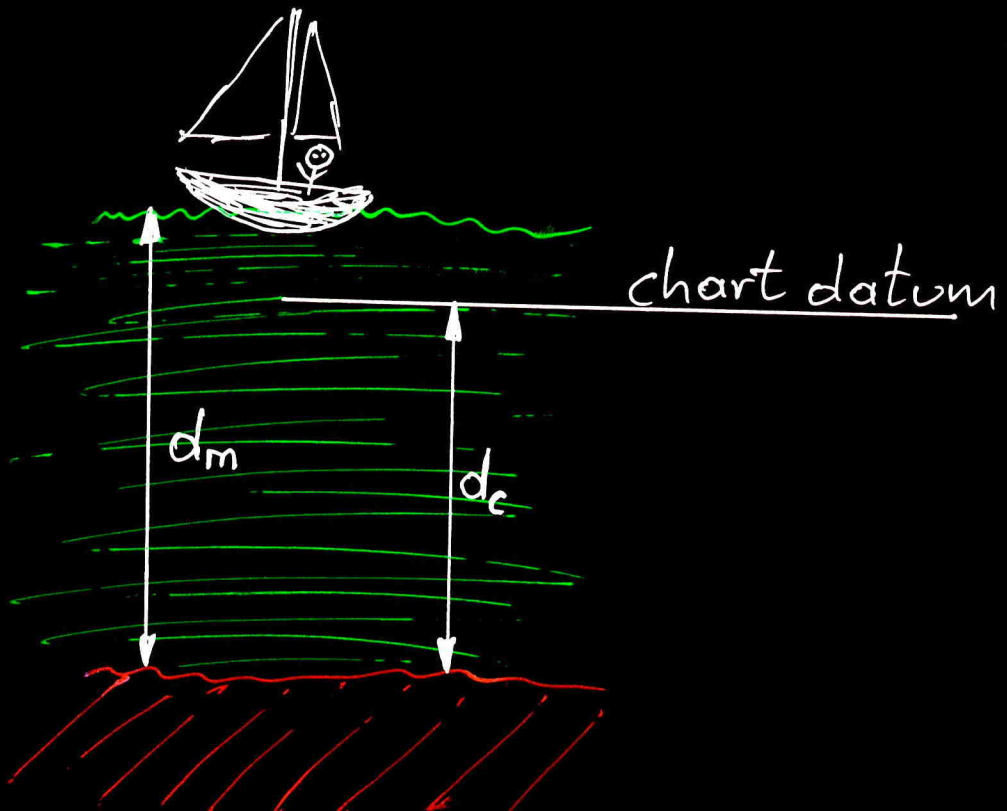
Surveying Depths

- Define a chart datum → Which ?
- Measure depth → How ?
- Compute back (time, tide tables, ...)



Measure d_m

↓

Compute d_c

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Conclusion

- Sea chart survey is not trivial.
- Data accuracy is vital.
- Sea chart survey may raise trust problem.
- Depth survey is prone to user errors.
- Thoughtless editing may harm people.

What can you do now?

We need ...

- brain power
- editing power
- programming power
- scientific power

QUESTIONS ?

Ask now or later down in the hackcenter at our desk :-)

THE END

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