The Zanclean flood hypothesis
Searching for independent evidence

Daniel Garcia-Castellanos, CSIC-Barcelona
Aaron Micallef, Malta U.
Angelo Camerlenghi, Trieste OGS
Ferran Estrada, CSIC-Barcelona
Gema Ercilla, CSIC-Barcelona
P. Bohorquez, Jaén Univ.
J.D. del Moral-Erencia, Jaén U.
R. Periáñez, Sevilla U.
J.M. Abril, Sevilla U.
Widespread erosion of the Mediterranean continental margins suggest the exposure of the seafloor by an evaporative drawdown of kilometric scale during the Messinian Salinity Crisis.

An erosion trough across the Strait of Gibraltar is the main support for a catastrophic refill of the Mediterranean after the MSC.

It runs from the Atlantic Ocean to the Mediterranean Sea and it’s visible in reflection seismic surveys, under a Plioquaternary sedimentary cover.

>400km long

2-10 km wide

Garcia-Castellanos et al., 2009, Nature
Messinian Erosion Surface map in Alborán (W Mediterranean).

Updated seismic survey + borehole data

Red lines show the proposed pathway and the channel excavated by the flood.
Two open questions are:

1) Where did that eroded rock (~1000 km$^3$) go to?

2) Is there an equivalent feature at the threshold where the W Mediterranean should have overtopped into the E Mediterranean?
Attempting at answering those questions, what follows is partly published in this recent article (open Access):

Evidence from
• the Alborán Sea seismic profiles
• Ionian Sea seismic profiles
• Numerical modeling
Where is the erosion/deposition occurring during the flood?
Hints from 2D hydrodynamic modeling:

Shear stress $[\text{Pa}] = \rho_w \times \text{fric\_coeff} \times \text{vel}^2$
Calculated from the setting by Períañez & Abril, 2015
Peak discharge of the Zanclean Flood (100 Sv)

Periañez et al., 2019
Similar hydrodynamic modeling at the Noto Canyon and the western Ionian Basin (offshore Sicily)

(a) Calculated water flow velocities at rising water levels of the E Med. between -2400 to -1700 m.

(b) Calculated velocity field for a smaller flood event with discharge of 20, 15, 10 and 5 Sv.

The area of unit 2a is shown by a black line.

Figure 11: (a) Estimated water flow velocities for water levels between -1700 and -2400 m in the Ionian Basin. (b) Estimated water flow velocities of a theoretically smaller flood event with discharge of 20, 15, 10 and 5 Sv. The area of unit 2a is denoted by a black line.

Spatola et al., submitted
2. Seismic stratigraphy of western Ionian Basin

Micallef et al., 2018, Sci. Reports
2. Seismic stratigraphy of western Ionian Basin

Unit 2:
- 160 km x 95 km
- Maximum thickness: 760 – 860 m
- Volume: 1430 – 1620 km³
- Pre-stack depth-migration seismic velocity: **2.3-2.6 km/s**
  
  => No gypsum

Interpretation:
**deposit** of material eroded and transported across the Sicily Channel once the western Mediterranean Sea level reached the sill during the **Zanclean megaflood at the end of the MSC**

Micallef et al., 2018, Sci. Reports
Outburst floods from overtopping lakes
Can we predict water discharge from basin size? (we can’t)

Peak flood discharge estimated at 82 overtopping lakes (Pleistocene, dams, and experimental)

Garcia-Castellanos & O’Connor, 2018, Sci. Reports
A prominent example: Lake Bonneville (today’s Salt Lake, Utah, USA)

Constraints:
- Level fall from Bonneville to Provo levels (120 m outlet incision).
- Lake outlet geometry: ~1600x120 m section.
- Estimations of peak discharge: ~10^6 m^3/s

17.5 ka, Pleistocene flood.
- Barrier: Consolidated fluvial fan

Abril et al., 2018 J Hydrol.)

Bonneville (Datum 1552 m)
Other outburst floods from overtopping lakes

Case scenario: Lake Bonneville spillway (Malde, 1968; O’Connor, 1993)
>10m boulders rolled and rounded by megaflood
Missoula floods erosion & transport in the Scablands (Wa, USA)

Transported in suspension??

Dry falls - Amphitheater-headed canyons
Noto canyon (Sicily): a 2,700-m-deep amphitheater-headed canyon

Horseshoe shape
Base at -2,700 m < 100 km³

Micallef et al., 2018, Sci. Reports
Megaflooding erosion features

Potholes Coulee, WA, USA. Similar to Dry Falls. $10^7$ m$^3$/s
Pleistocene Altay outburst flood:

$10^7$ m$^3$/s

17 ka

Carling et al., 2009
Possible megabar deposits flanking the erosion channel in the Alborán Sea
Take home

• A Mediterranean drawdown implies large erosion rates at sills during the refill between subbasins
  – Faster than tectonics if headloss > 10’s m
  – *Catastrophic* if headloss > 100’s m

• Catastrophic flooding implies a previous large drawdown in the Mediterranean.

• Flood deposits can validate/refute the flood hypothesis. Two sets of deposits in the Alborán and the Ionian seas are compatible with archetypical megaflood deposits, though independent assessment (drilling) is needed.