# Anomalous depressions – a view from the west

Dr Philip Collins

Brunel University

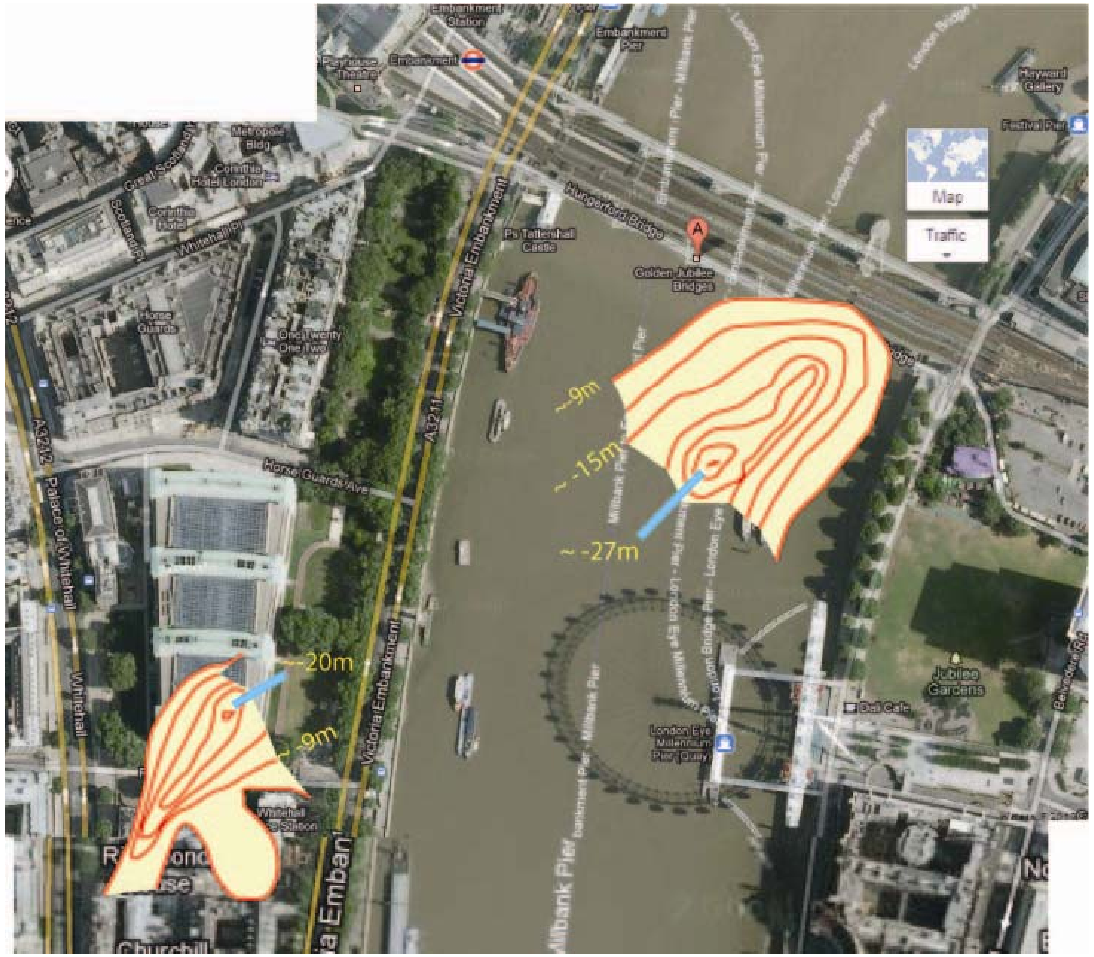
# Acknowledgements


- Much of the evidence presented comes from previous work, particularly by Prof H.L. Hawkins and Dr D. Hill
- Thanks also to Prof Peter Worsley for introducing me to the Kennet Valley sites presented

# Anomalous depressions – a view from the west

- Problems with the hollows in London
- Hypotheses
- Locations
  - Brimpton
  - Woolhampton
  - Ashford Hill
- Pingo remnants?
- Conclusions and way forward

# Problems with accessing hollows in London

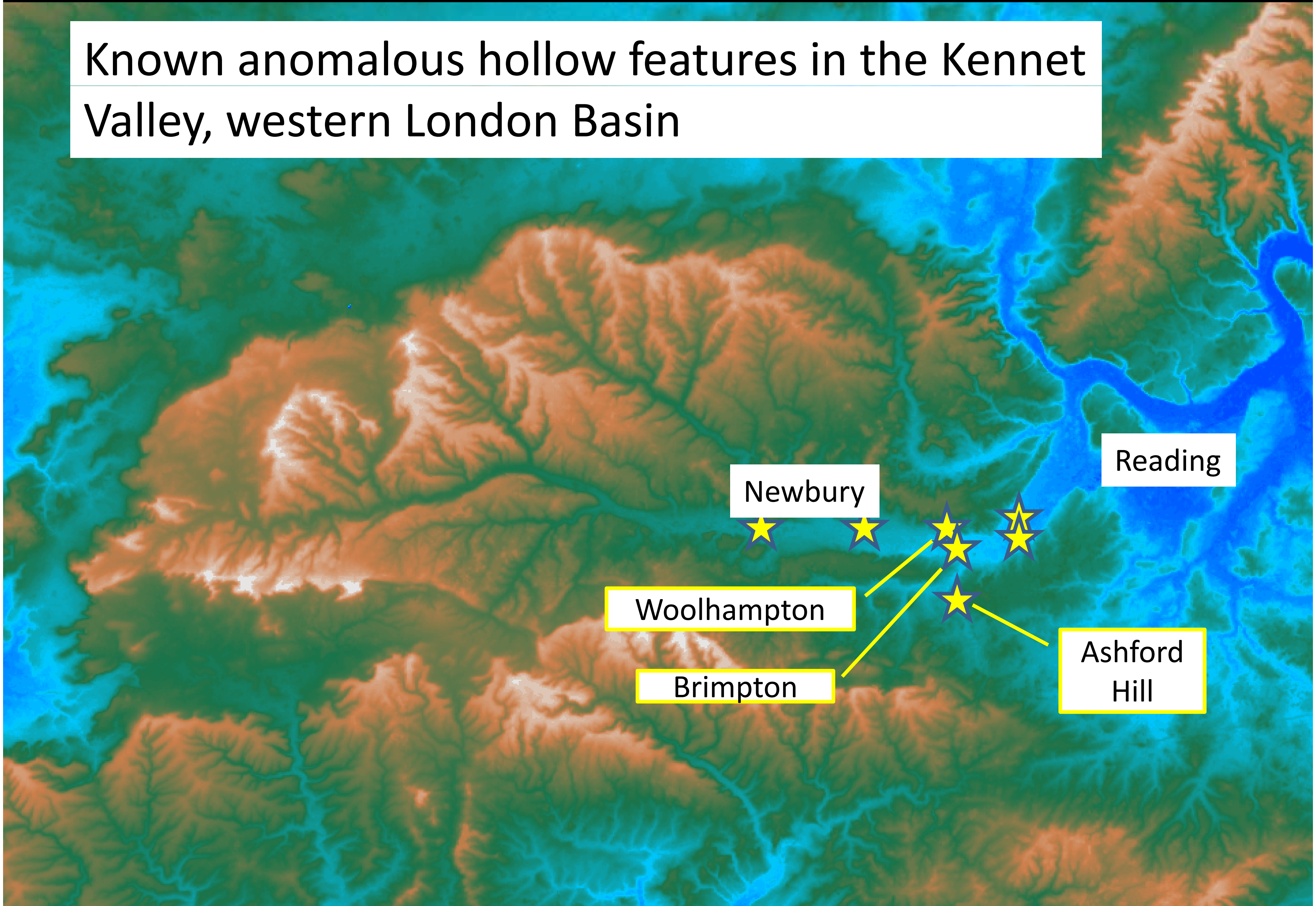



Contours after Berry 1979
Photo-image: Google Maps

# Hypotheses

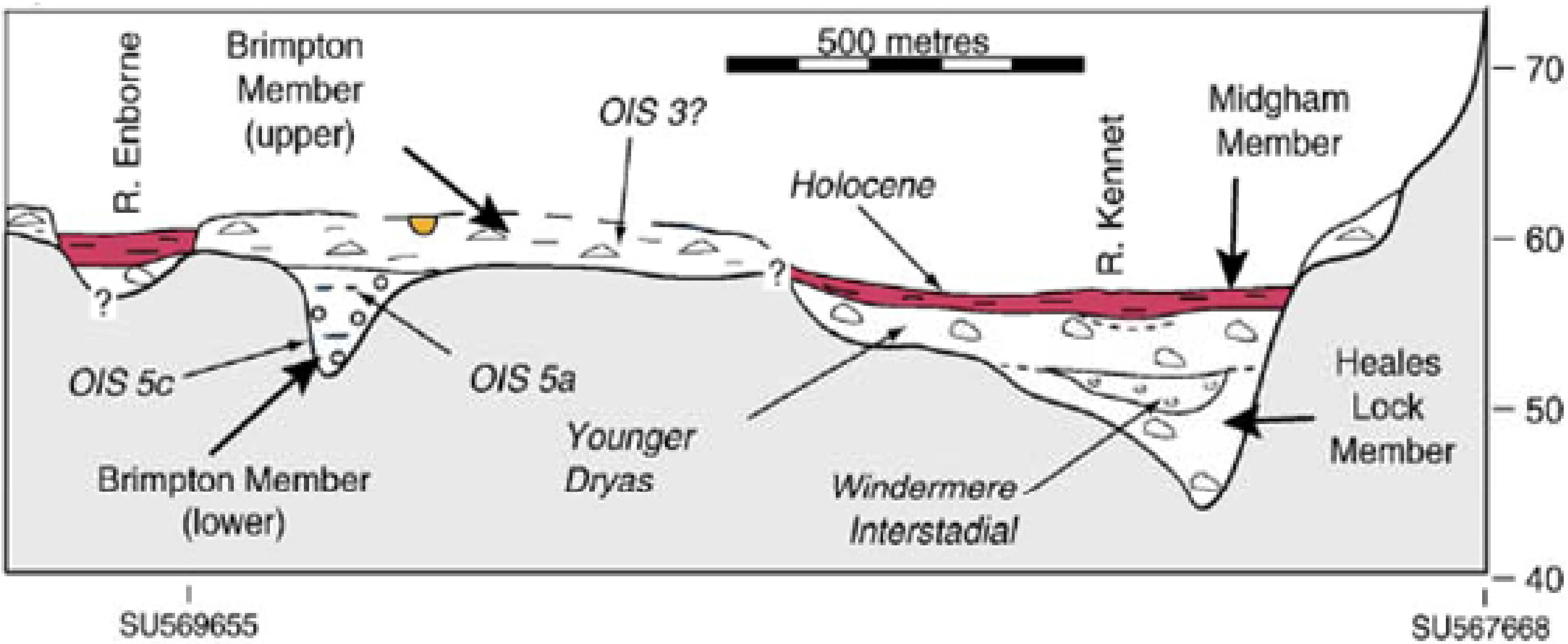
- Top-down: Scour
  - Channel confluence hollows
  - Deeply incised gullies (i.e. not actually hollows)
- Bottom-up: ‘Simple’ subsidence
  - *In situ* Chalk collapse
- Relicts of ground ice (‘pingos’)
- ‘Complex’ subsidence`
  - *Ex situ* Chalk collapse
  - Consolidation settlement

# Known anomalous hollow features in the Kennet Valley, western London Basin



# Accessible hollows, Brimpton-Woolhampton (1970s-80s and 1990s)

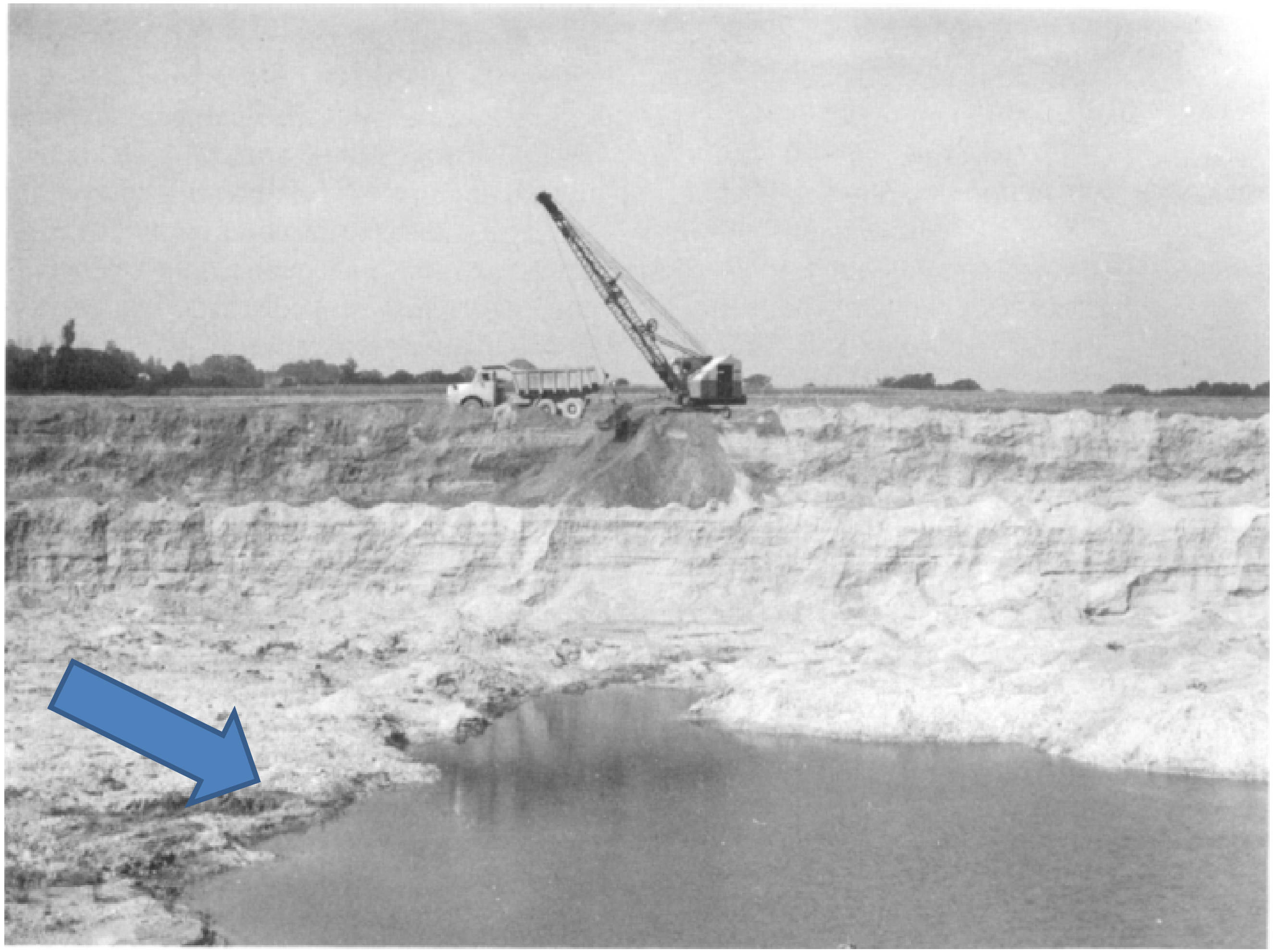
# The Brimpton-Woolhampton Hollows




Two features, different age infills

Worsley & Collins 1995; Collins et al. 1996, 2006

# Inside the Brimpton Hollow

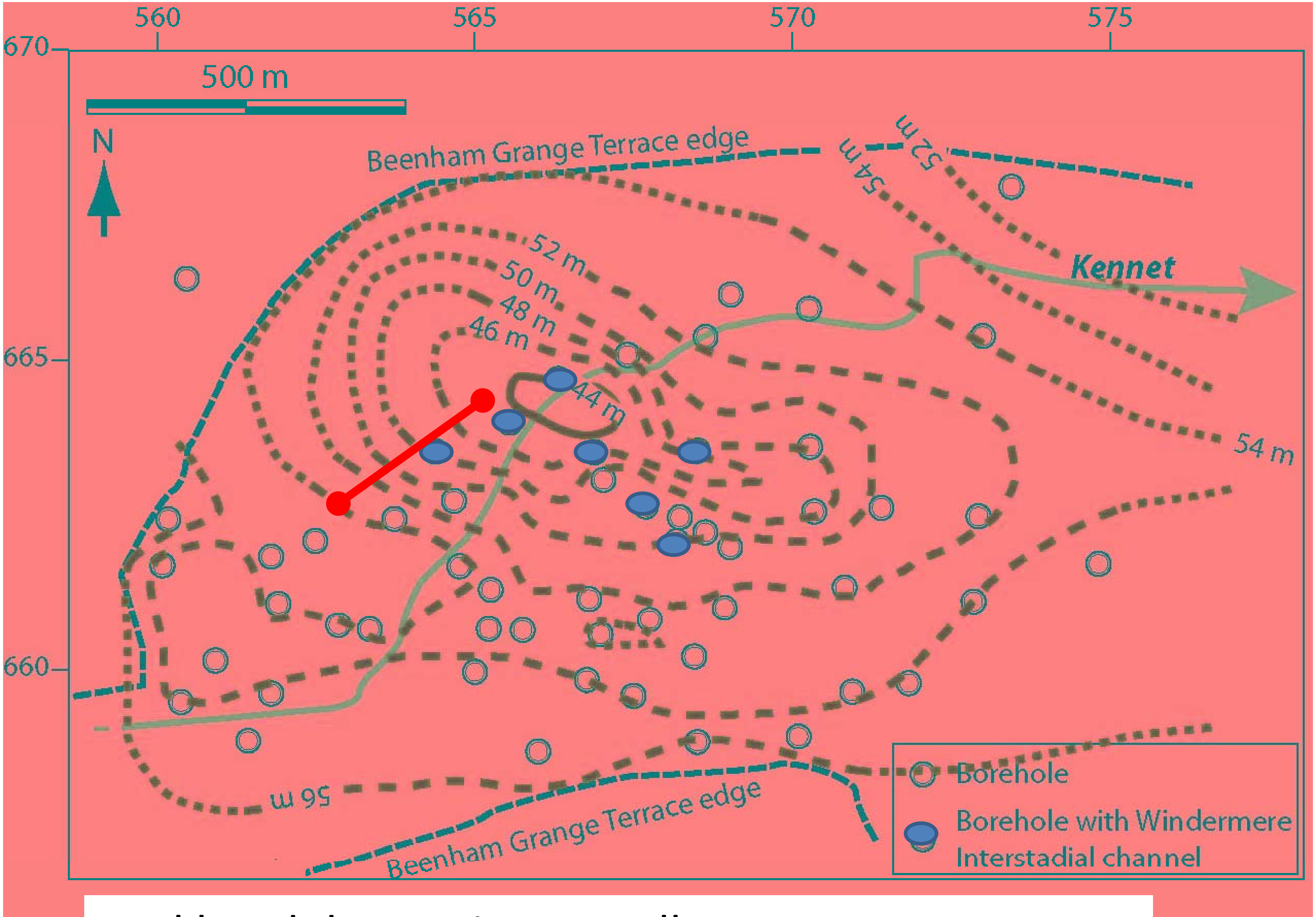


<30
- ?20 ka BP

>100
-74 ka BP

**Fig. 2.** The pit face in October 1979. The descent of the London Clay surface into the depression is apparent as is the paraunconformity between the lower sandy gravels and the upper silty gravels (from negative PW 1980-00-3A).

Worsley & Collins 1995




Rockhead depression, Woolhampton. Collins et al. 2006

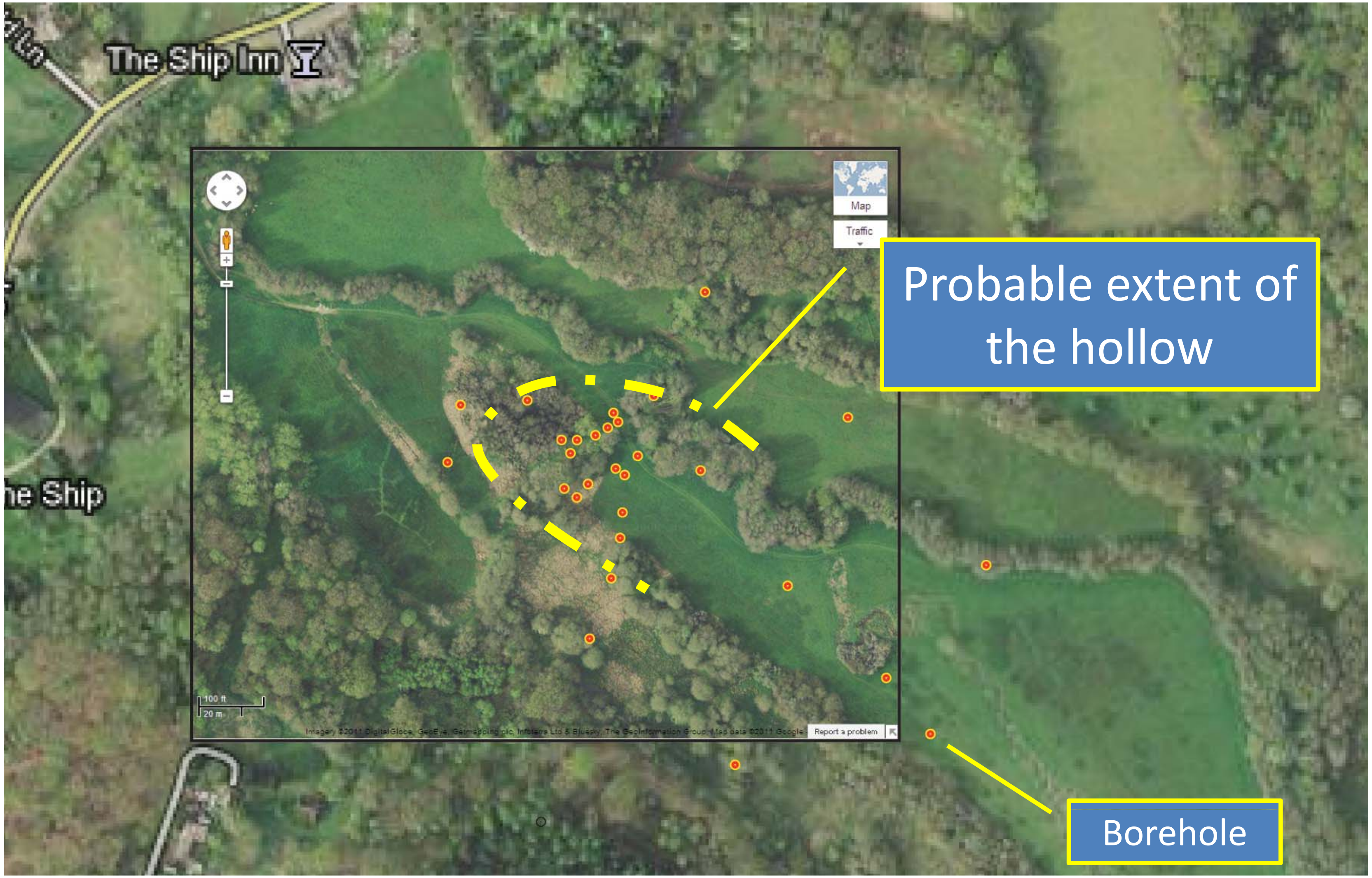

The Woolhampton Hollow (Late Devensian Lateglacial infill)

•Infilling over <10,000 years (top 4-6 m in ~1,000 years)

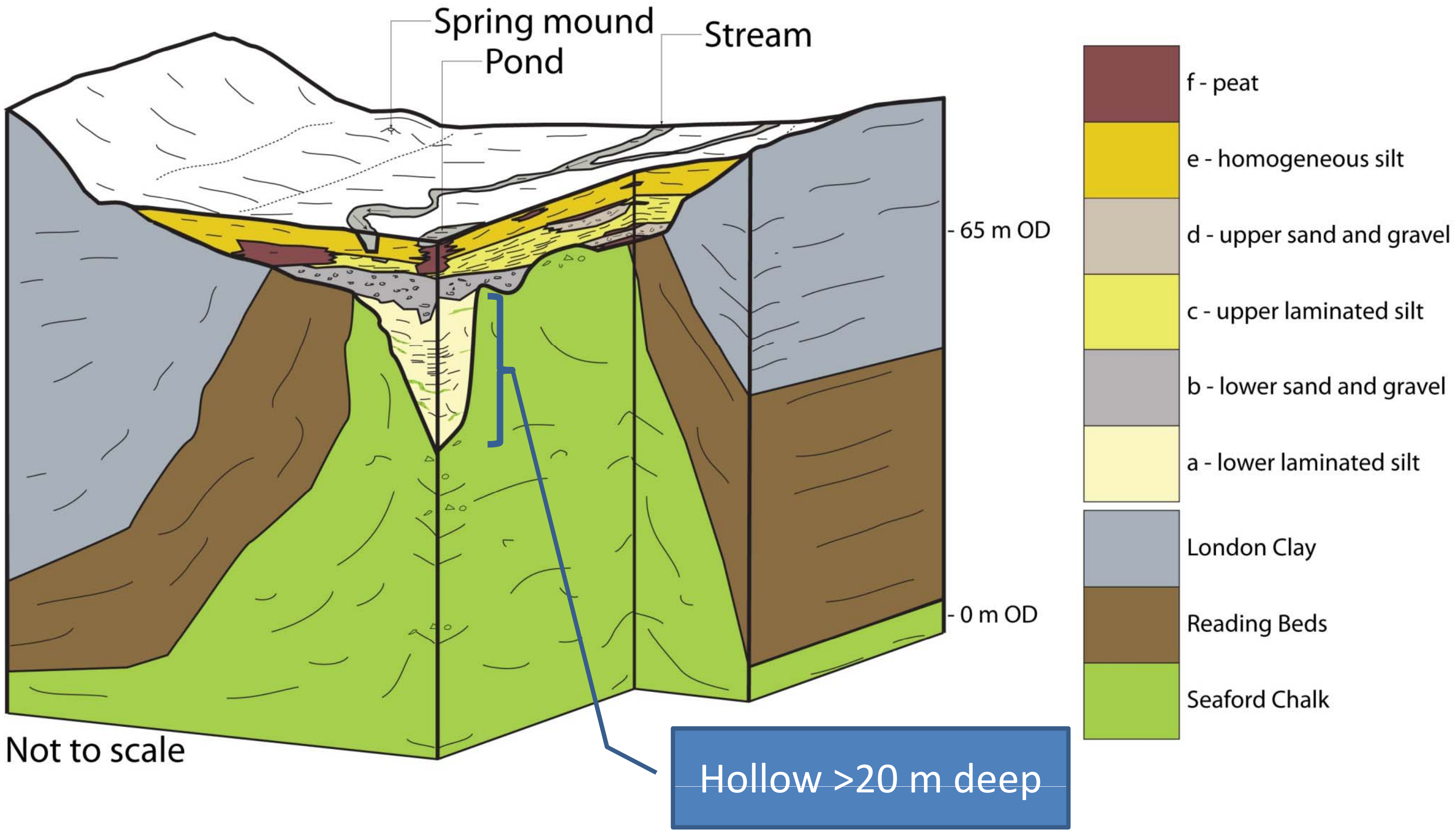
•End of MOIS 2 (periglacial-temperate-periglacial)

•Tilted bed (dark in photo), parallel to surface of London Clay

# Ashford Hill: existing boreholes (H.L. Hawkins), 1980s (D. Hill)



# Conceptual model of the Ashford Hill site




Derived from data and drawings in Hawkins 1953 and Hill 1985, and field observations 1991-2013

Basal laminated silts from the Ashford Hill hollow (~27 m depth)

- Varve-like deposition (seasonal?)
- Evidence of mudflow infill from steep margin s
- Tilted and faulted beds

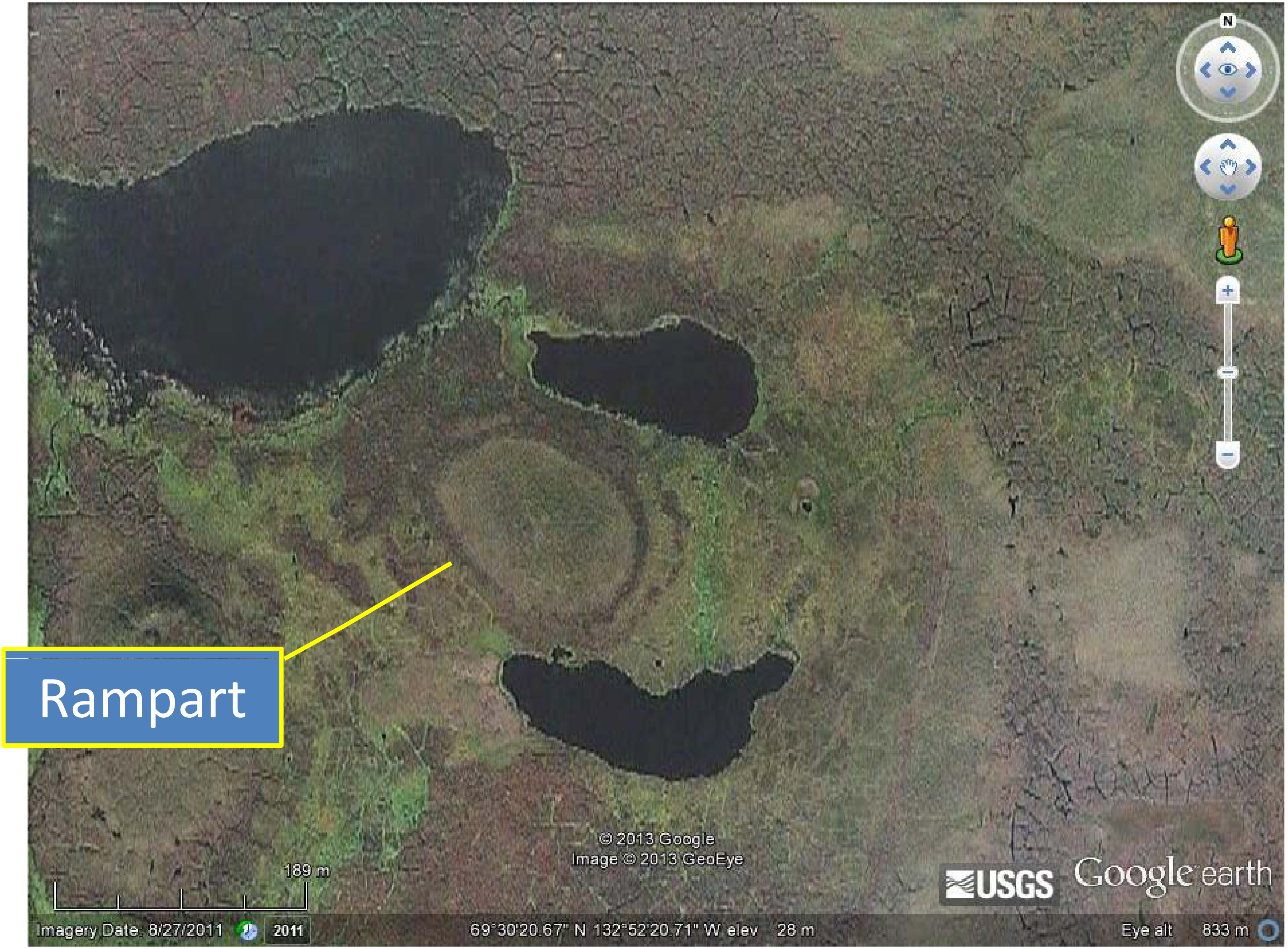
# What formed the hollows?

- Tilted beds – differential subsidence

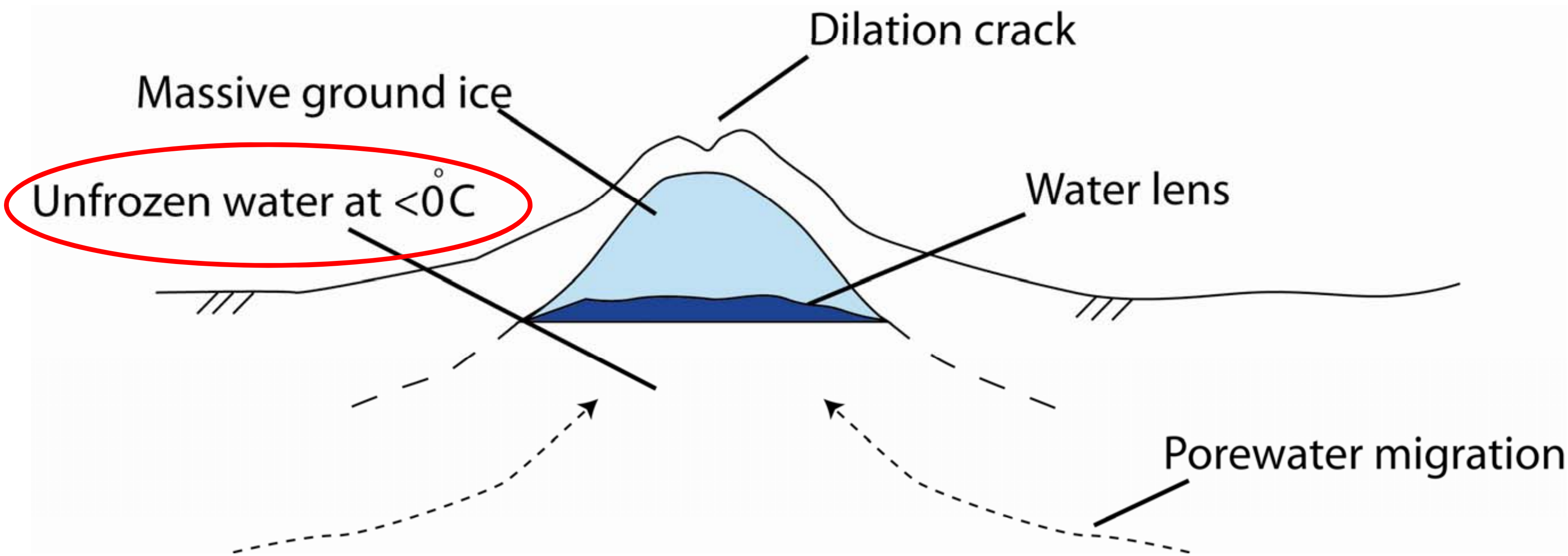
- Consolidation settlement?
  - almost certainly a factor once hollow was present
  - Rapid deposition & loose, saturated sediments
  - Dissipation of excess porewater pressure
- Thaw collapse (thermokarst)
  - Requires former presence of large volume of deep segregated ground ice (i.e. a pingo?)

# Active pingo, Mackenzie Delta, Inuvik

# Pingo remnant, Mackenzie Delta, Inuvik



# Internal structure of a hydraulic pingo




Modified after Mackay 1998, fig. 4

# Diagnostic features of a relict pingo

- Ramparts around depression
- Dilation cracks extending through ramparts
- Mass wastage and meltwater deposits - ± radiating out from centre
- Undisturbed material underlying centre of hollow  from below level at which segregated ice formed
- Frost-susceptible soils (for cryosuction) and/or focussed water supply

Adapted from Mackay 1998

# Diagnostic features- actual evidence

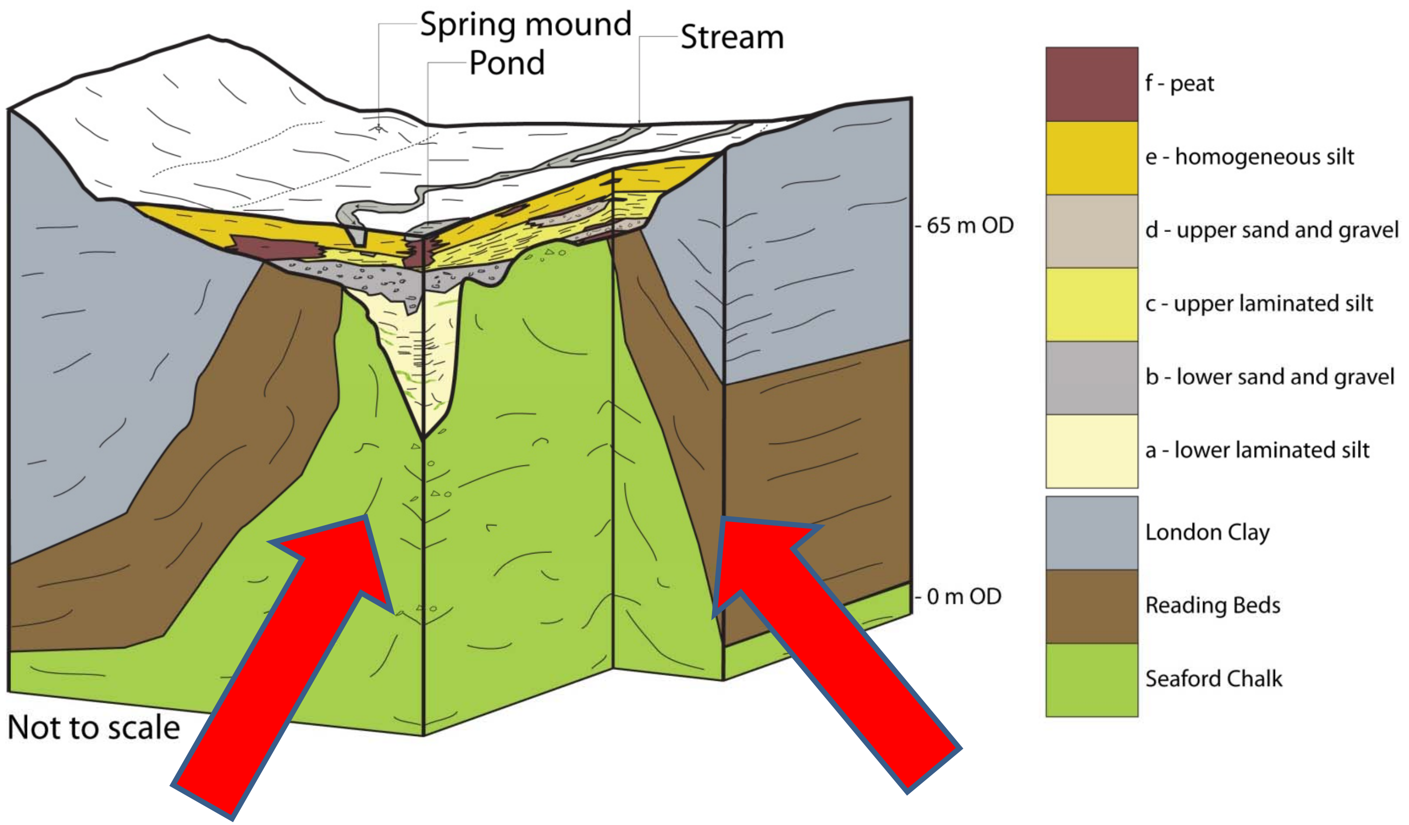
- ~~Ramparts around depression~~
- ~~Dilation cracks extending through ramparts~~
- ~~Mass wastage and meltwater deposits - ± radiating out from centre~~
- ~~Undisturbed material underlying centre of hollow from below level at which segregated ice formed~~
- Frost-susceptible soils (for cryosuction) and/or focussed water supply

Adapted from Mackay 1998

# Further issues with the ground ice hypothesis

- Uncertain **when** hollows formed (still forming?)
- Did this coincide with **permafrost** presence and thaw (and is the evidence for **deep** permafrost really conclusive?)
- Could ground ice form such a **deep hollow**?
- Why are there (*apparently*) **none of these features** beneath the higher terraces (i.e. palaeo-valley floors)?

# Focussing on the hollow <u>may be missing the bigger issue!</u>



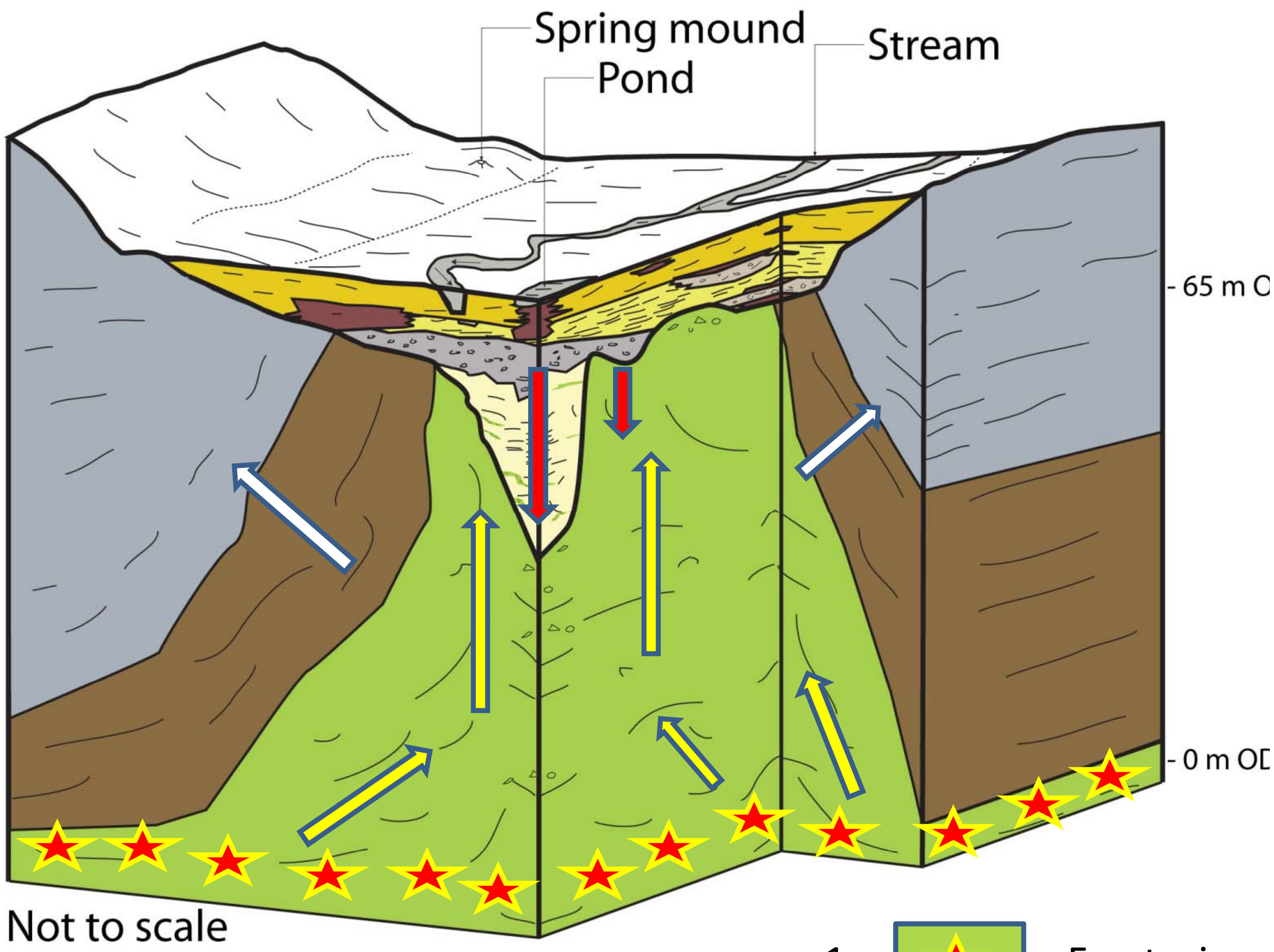

The diapir and tilted/uplifted Tertiary strata at Ashford Hill are **much** larger than the hollow

- *Brecciated* Chalk from the Ashford Hill diapir

- Mixed with sand-silt matrix (where from?)
- excess pore water pressure
- doesn’t appear to be due to drilling method

- ‘*Diamict*’ and flow structure in ‘chalk head’ from the Ashford Hill diapir

- Evidence of mixing and injection
- \- excess pore water pressure
- \- doesn’t appear to be due to drilling method




Unknowns:

- Relationship to valley formation
- Timing of brecciation
- Timing of injection/heave
- *Exact* timing of onset of subsidence
- Cause(s)

# Relative sequence of onset of processes at Ashford Hill

1. Fracturing of Chalk
2. Injection of Chalk putty and breccia
3. Heave of Reading Beds & London Clay
4. Subsidence

# What caused the diapir?

Chalk had to be brecciated *and* transported

- Freeze-thaw?
  - At 60 to >100m depth?
- ‘Simple’ pressure differential
  - Differential loading enhanced by scour
  - Enhanced by permafrost cap?
  - Would explain ‘bulging’ but could it explain migration, mixing and injection at depth?
- Abrupt pressure differential?
  - Rapid thaw removing valley floor permafrost cap?
  - Seismic event(s)?

# Conclusions

- Many (at least) of the hollows reflect subsidence
- Chalk diapirism is linked to some (at least)
- We have a list of candidate processes but insufficient evidence to properly test these:
- Deep boreholes
- Geophysics
- Hydrogeology
- Geotechnical properties
- Dating

Detailed 3D models of the hollows, and underlying and surrounding strata