The Bosumtwi impact structure, Ghana: Deep drilling unravels the formation and history of a well-preserved young impact crater

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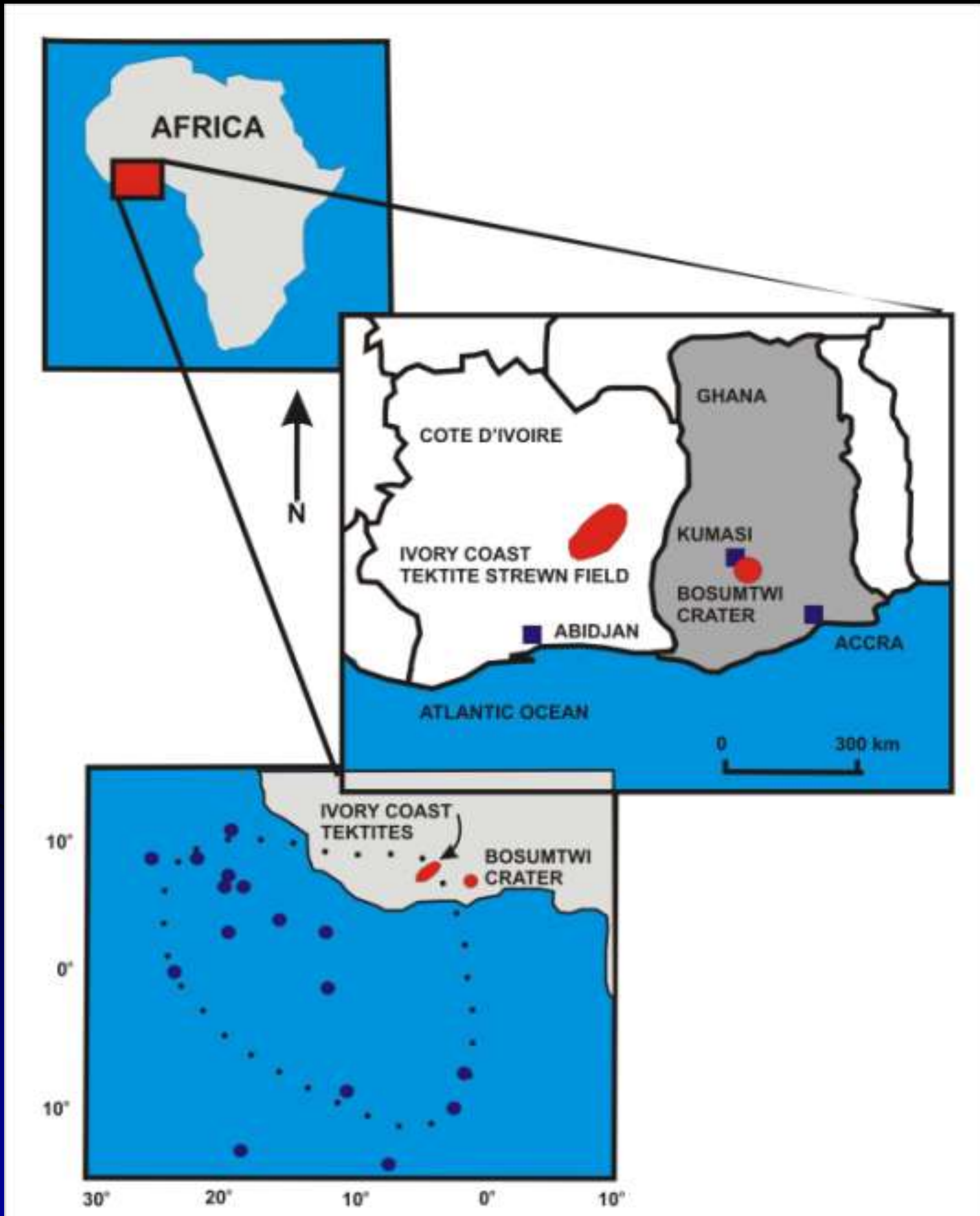
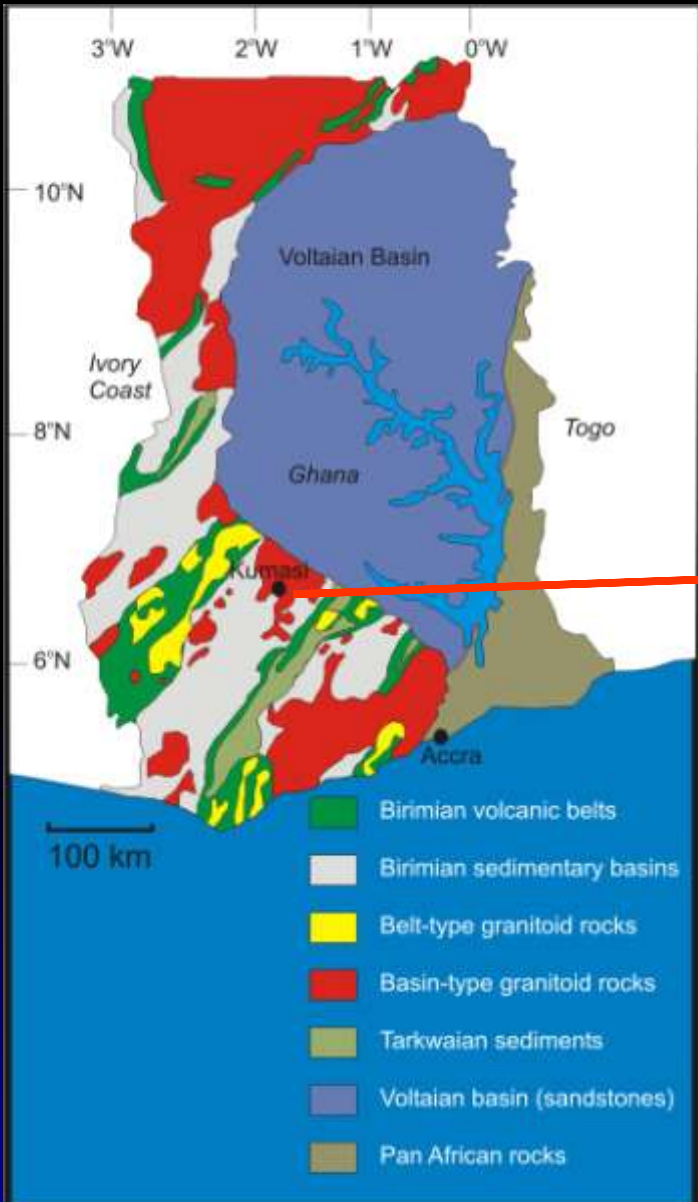
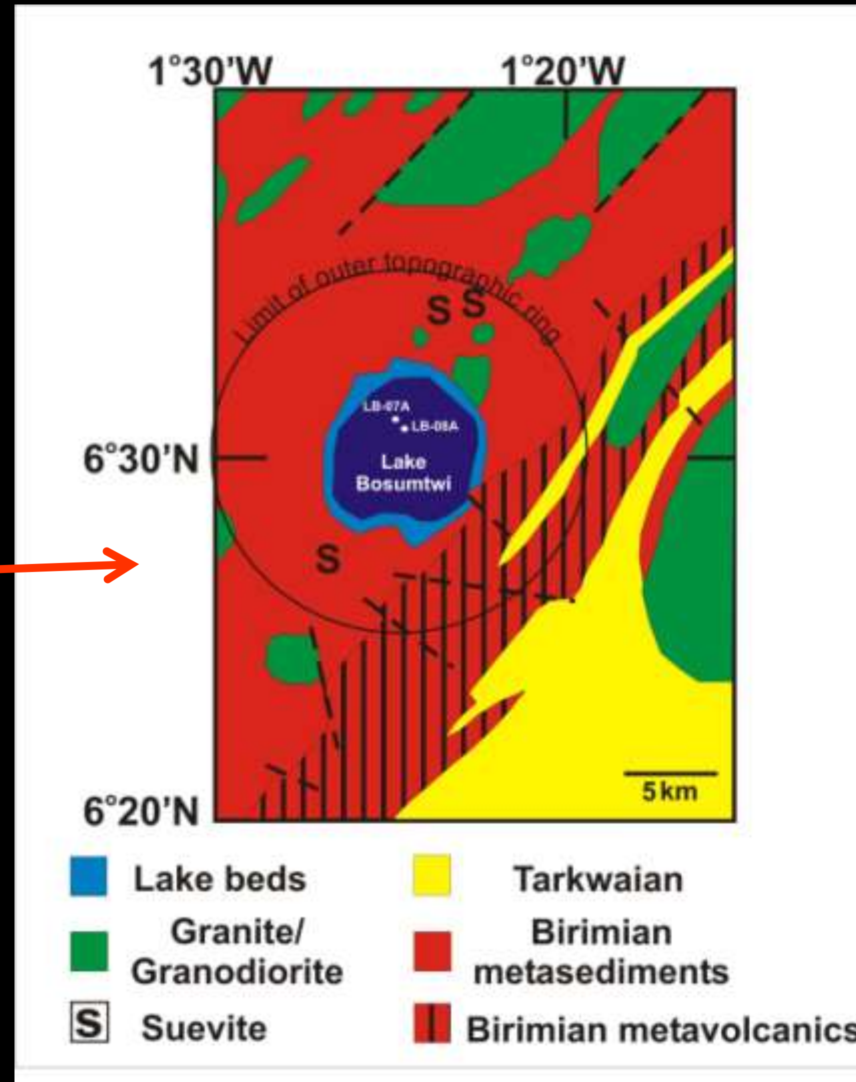


Bosumtwi Impact Structure, Ghana

- Located 32 km SSE of Kumasi, Ashanti Province, Ghana
- Medium-sized (10.5 km) young (1.07 Ma), complex impact structure
- Source crater for 1 of 4 known tektite (+ microtektite) strewn fields (the Ivory Coast tektite strewn field)
- Filled with the 8.5 km diameter, up to 75 m deep Lake Bosumtwi
- Contains ~ 1 Ma of lake sediments, recording the palaeoclimatic changes of the region, including the seasonal migration of the Intertropical Convergence Zone

Regional Geology: Target Rocks

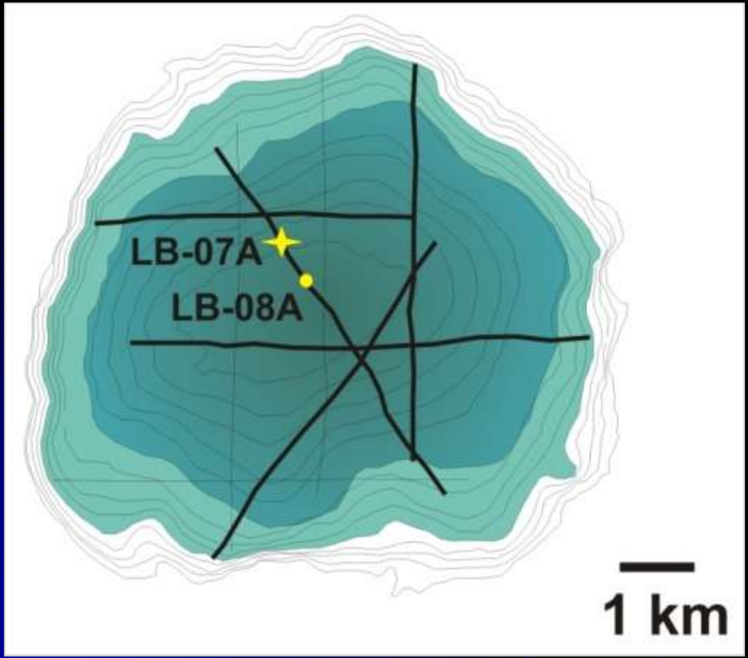


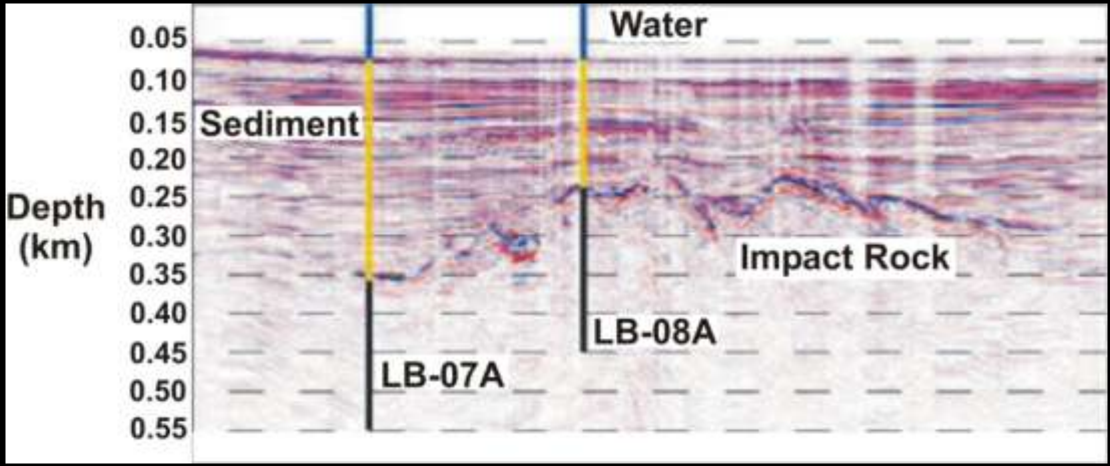


- 2.1-2.2 Ga Birimian metavolcanics & metasediments (heterogeneous, steeply dipping, interbedded phyllites, schists, metagreywackes, shales); granite intrusions
- Suevites (melt-bearing impact breccias) N & S of the crater

ICDP Drilling at Lake Bosumtwi

- 16 drill cores (14 sediment cores, 2 hard rock cores) were obtained in late 2004
- Two hard rock cores (LB-07A and LB-08A) were drilled into the deepest section of the annular moat (to 540 m depth) and into the flank of the central uplift (to 450 m depth), respectively
- Essentially the entire impactite crater fill and upper section of the crater floor were sampled





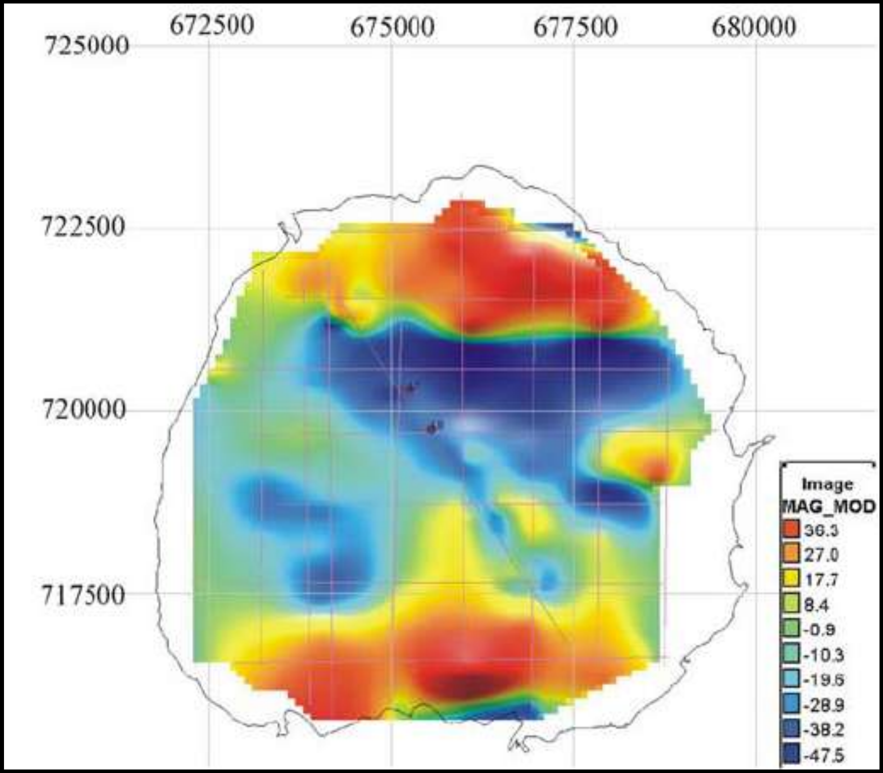
After Scholz et al. (2002) & Karp et al. (2002)

Pre-Drilling Predictions

- Geophysics - Seismic + Gravity data (Karp et al., 2002; Scholz et al., 2002) = 4 layers of water, sediments, impact breccia (melt), basement; double peaked central uplift.

  - Magnetic data (Plado et al., 2000) = substantial volume of melt rock (200 m thick; Artemieva et al. 2004)

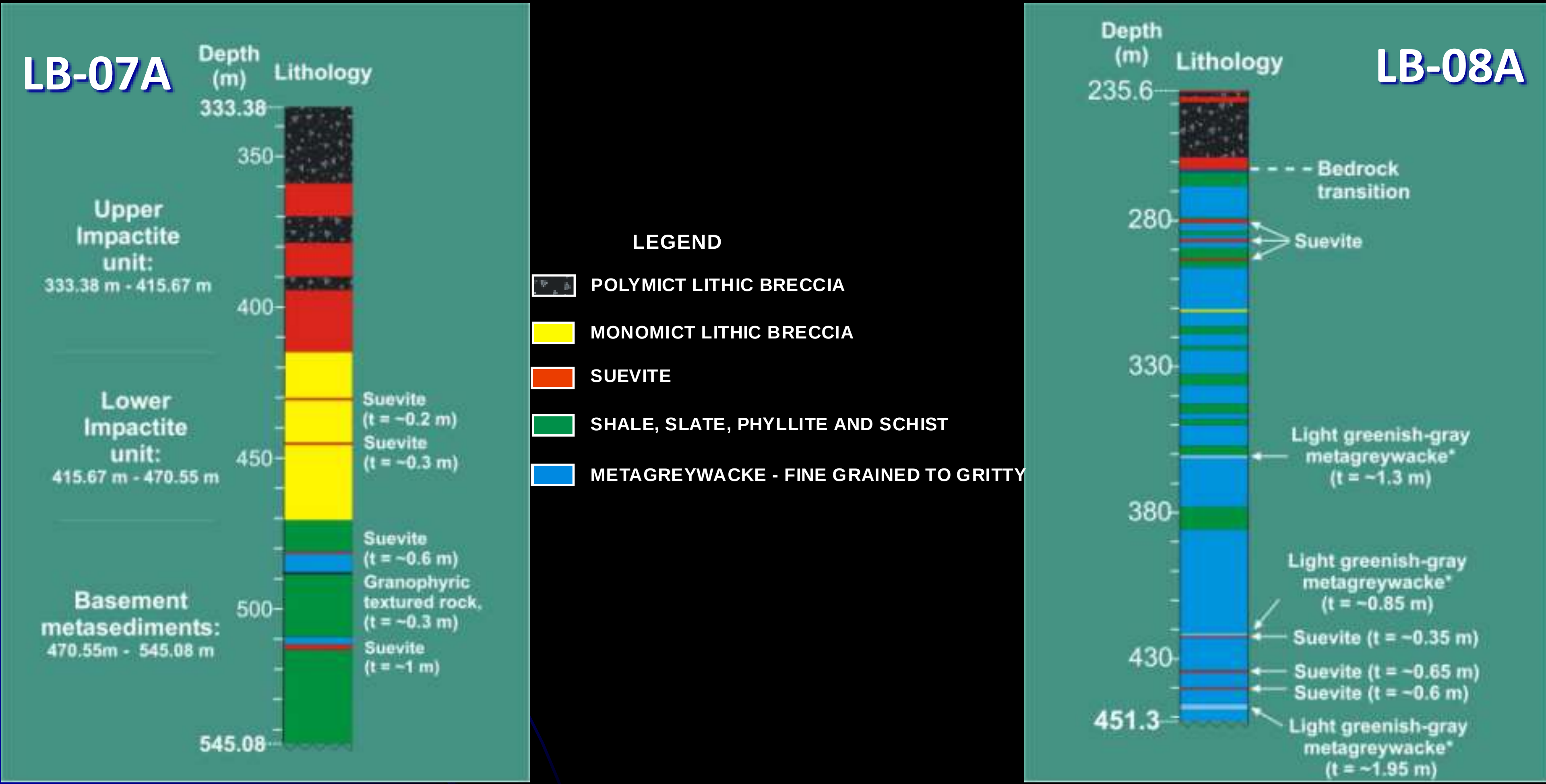
- Geology of target rocks – dominated by granite, then metasediments (Koeberl et al., 1998)
- Shock degree of impactites– predicted to contain > 50% melt, high degree of shock (constraints from suevites outside of the crater; Boamah & Koeberl, 2003)



Magnetic Signature of the Bosumtwi structure: After Ugalde et al. (2007)

Post-Drilling Findings 1: Within the crater

- Lithostratigraphy of both cores: **Minor** granite, metagreywacke = shale (implications for the numerical modelling). Notable primary and secondary calcite component.
- Seismic and gravity predictions confirmed: basement > impactites > lake sediments > water. BUT! No melt layer (& shock degree less than expected in impactites).

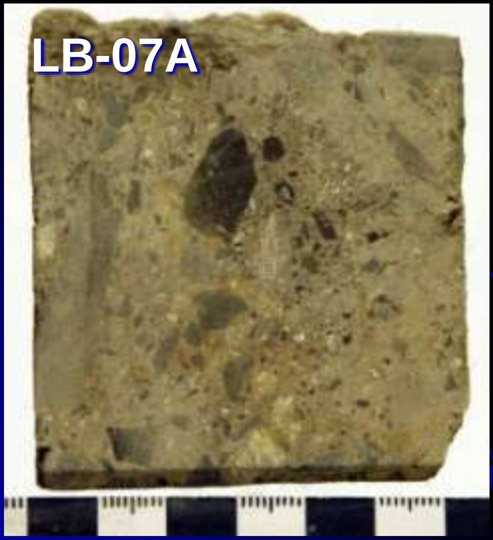


After Coney et al. (2007)

After Ferrière et al. (2007)

Post-Drilling Findings 2: Within- vs. out-of-crater suevites

	Within-crater suevites	Out-of-crater suevites
Maximum vol% melt	18 vol% (av.: 5.4 vol%)	60 vol% (av.: 37 vol%)
Maximum size of melt particles	1 cm	40 cm
Granite	< 0.1 vol% (<1 cm)	18 vol% (25 cm)
PDFs in quartz grains:	0.9	6.7
rel% with ≥2 PDFs		
Other features	Diaplectic glass-rare	Diaplectic glasses & *Ballen* quartz
Geochemistry	Depleted in Al_2O_3	Enriched in Al_2O_3
	Enriched in CaO	Depleted in CaO



But the out-of-crater suevites are different from each other too…

So what does this all mean?

Model constraints

A model must account for the following:

1. Differences in clastic components between the within-crater and out-of-crater impactites: granite, shale, metagreywacke, carbonate
2. More moderately to highly shocked material in the out-of-crater impactites than in the within-crater material
3. Differences in melt particles between the out-of-crater and within-crater impactites: size, abundance, shape, chemical composition (and the out-of-crater suevites differ from each other..)

Model possibilities

Traditional: Single ejecta cloud – fallout and fallback for suevite formation

Not possible – as suevites would have similar geological characteristics

Modified: 2 mechanisms for the out-of-crater and within-crater suevites

Out-of-crater: Fallout?
Accounts for more shocked material
But differences for N and S suevites?

↓

Differentiated ejecta cloud
(Heterogeneous, steeply dipping target rocks)

Within-crater: Fallback?
Lack of melt particles; shock effects

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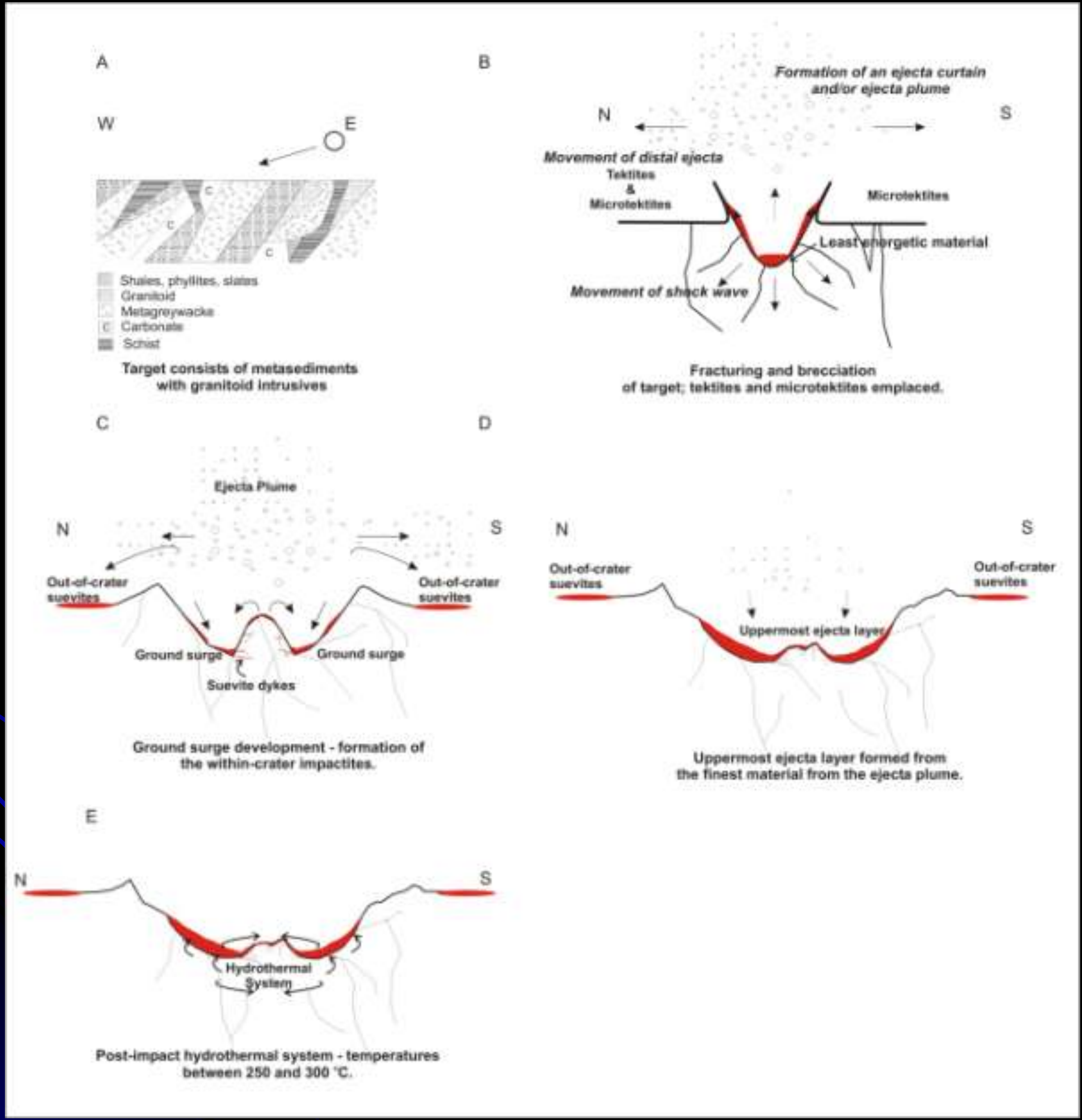
Ground surge mechanism for the within-crater impactites

Proposed Model



The ICDP deep drilling confirmed and disproved a number of pre-drilling expectations, highlighting the importance of first-hand observations in conjunction with other tools in impact cratering studies

Acknowledgements

- Sharon Turner, Janine Naicker, Allan Wilson, Alex Mathebula (Wits); Ralf-Thomas Schmitt, Lutz Hecht (Humboldt-Univ.); Bernard Peucker-Ehrenbrink (Woods Hole Oceanographic Institution); Freddie Roelofse (CGS) and SGS Lakefields.
- Forson Karikari, Daniel Boamah, Moses Quainoo and David Okyeame – the Bosumtwi team in Ghana
- Major funding sources for this project were ICDP, the U.S. National Science Foundation (NSF), the Austrian Science Foundation (FWF), the Natural Sciences and Engineering Research Council of Canada (NSERC), and the Austrian Academy of Sciences; National Research Foundation of South Africa, Jim and Gladys Taylor Trust Award
- Drilling operations were coordinated and performed by DOSECC, Inc.
- We appreciate the logistical support of the Geological Survey of Ghana (Accra) and the University of Science and Technology (Kumasi), and the assistance of the local people as well as tribal and government authorities, without whose support this project would not have been possible.
- The help of the Operational Support Group of ICDP (led by T. Wöhrl) was essential, as was the guidance of U. Harms (ICDP).

- L.C. would like to thank the **Mintek Mineralogy Division** for sponsorship to attend this conference

BOSUMTWI CRATER DRILLING PROJECT

HAPPY BIRTHDAY KEVIN & LEW!

Thank you