



# Improved Blasting Results with Precise Initiation

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## Better blasting....

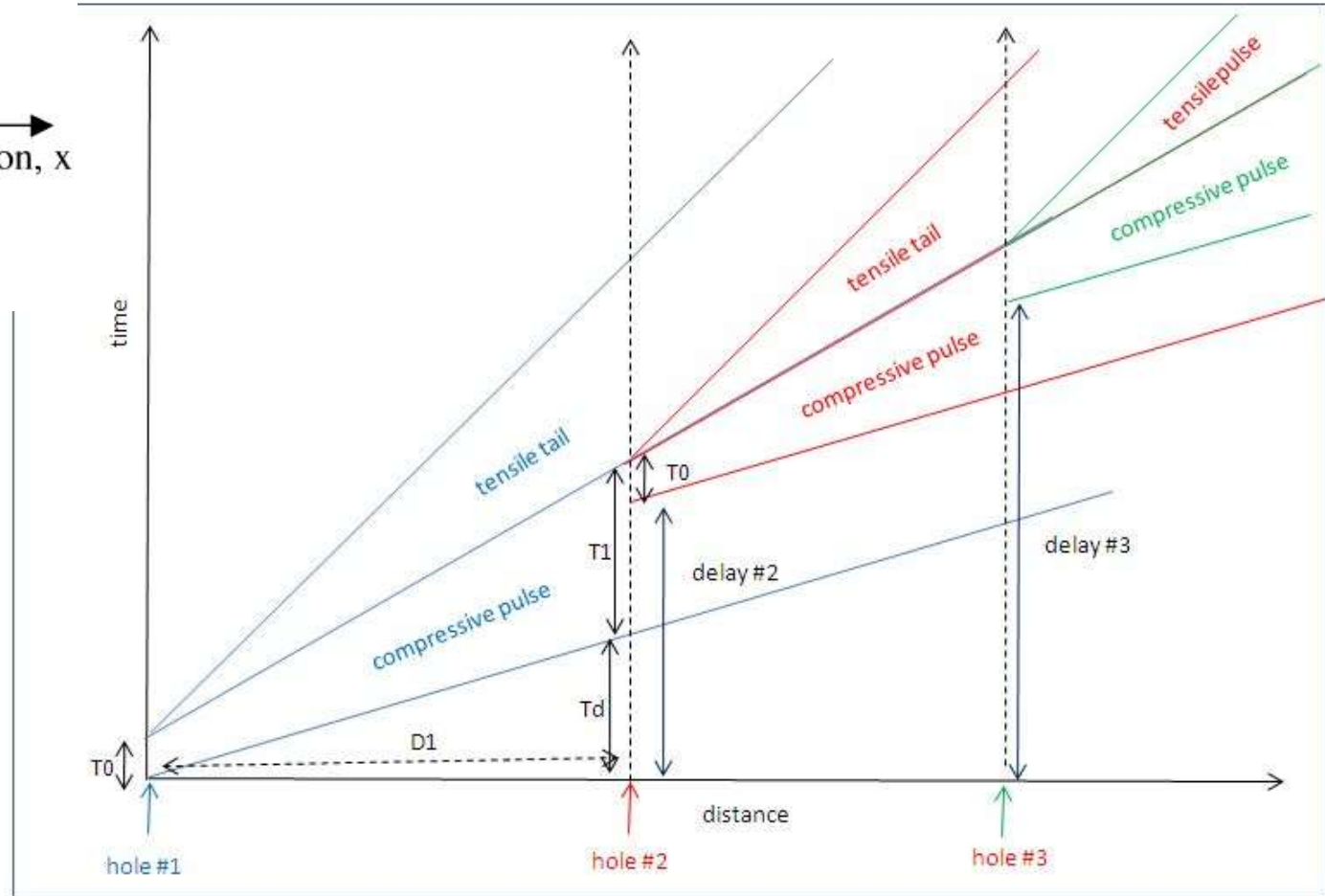
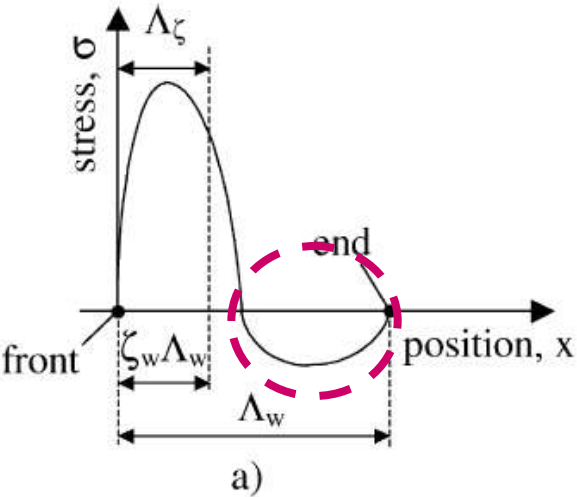
- Blasting = to fragment rock into suitable dimensions
- Improved fragmentation results in:
  - Reduced costs for blasting
  - Reduced costs for transportation of blasted rock
  - Reduced emissions
  - Reductions in energy consumption during crushing & grinding
  - Improved metal recovery



## Background and hypothesis

- Electronic blasting caps enable achieving wave superposition in rock blasting
- Fragmentation is improved in areas between blast holes where the tensile waves meet, overlap and interact (Rossmanith (2002))
- Practical experiences show that improved fragmentation, throw, swelling, and diggability, can be achieved through this
- Quantitative computational models that describe this phenomenon are lacking







## Project objectives

- Achieve a better frag-mentation, throw and other results from blast in quarries and mines
- Study the exten-sion of Rossmanith's concept to a three-dimensional geometry by identifying the rock vol-umes within a blast where the wave interaction from neighboring blast holes may create additional damage





## Project approach

- Develop a methodology for dynamic numerical (computer) simulations of blasting
- Full-scale field tests using electronic blasting caps
- Numerical analysis of laboratory (model scale) tests and full-scale field tests





## Project organization

- **Participants**
  - **Luleå University of Technology and Swebrec**  
*Laboratory tests, monitoring, computer modeling*
  - **Boliden Mineral AB**  
*Full-scale field tests*
  - **LKAB**  
*Field test data, applications*
  - **Engineering Research AB (ERAB)**  
*Computer modeling*
  - **Itasca Consultants AB**  
*Project management*



## **Project activities**

- **Re-start of project – new project leader, new resources:**
  - Project start: Feb 1, 2011
  - Project end: Dec 31, 2012
- **On-going activities:**
  - Computer simulations
  - Field tests



## Computer simulation of blasting

- **Challenges:**
  - Representative material model for rock (DIANE material)
  - Replicate rock response to large pressure (GPa) and subsequent damage
  - Material model for the explosives
  - High resolution of numerical model

***This is at – or beyond – the current state-of-the-art!***

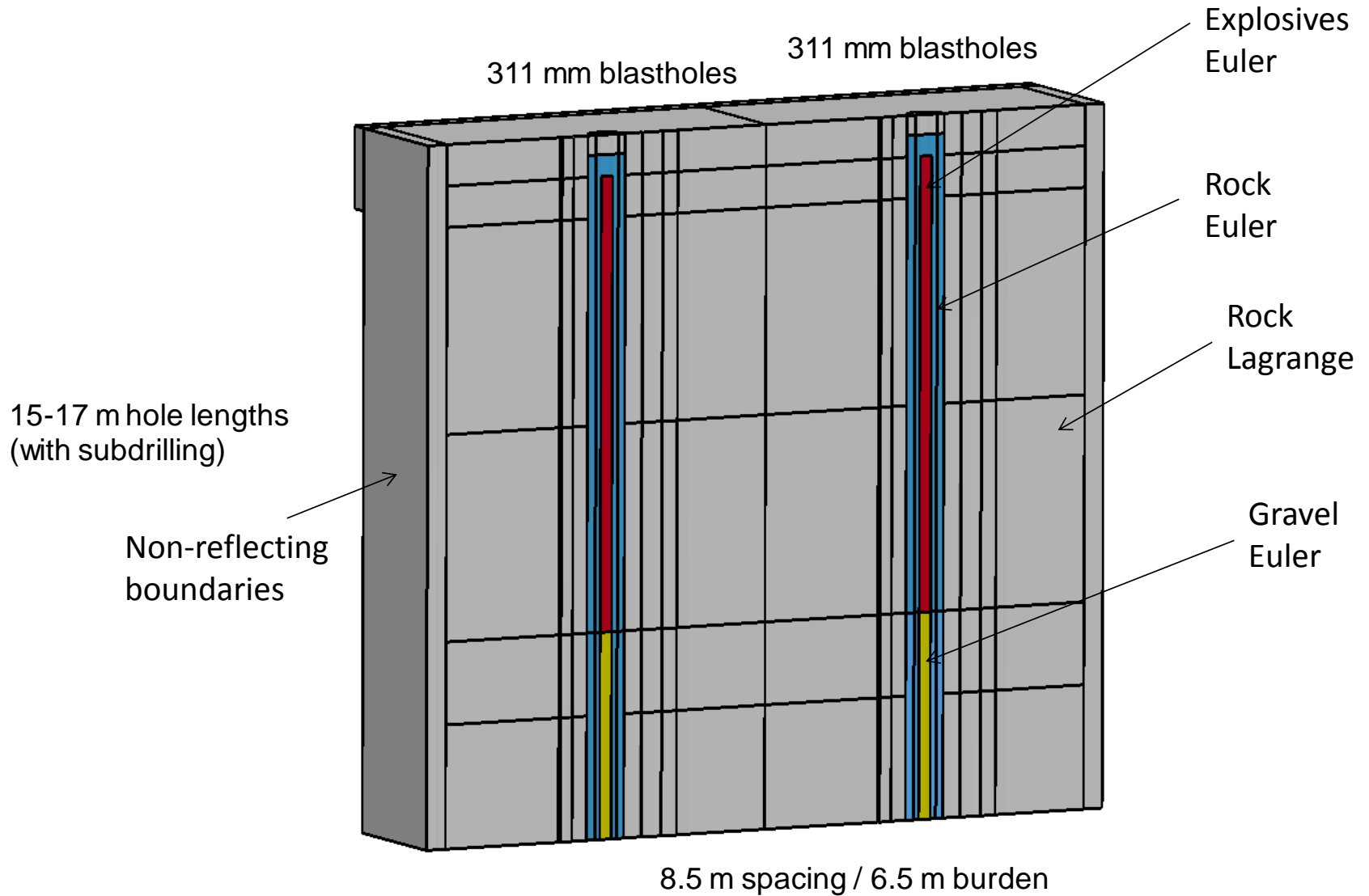


## Computer simulation of blasting

- **Evaluation of computer codes and choice of approach**
  - *LS-DYNA* computer code
  - Euler and Lagrange element formulation (in combination)
  - Method for interpreting fragmentation based on calculated damage (yield)
  - Different constitutive models (including the *RHT* model)

Model of subset of Aitik bench blast:

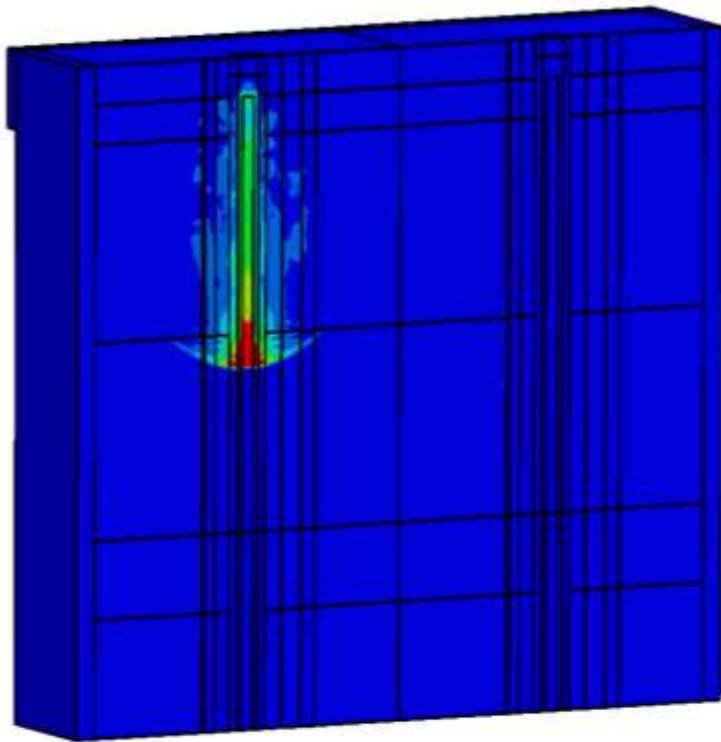
*4 blastholes; 20 million elements; 50-60 mm resolution*



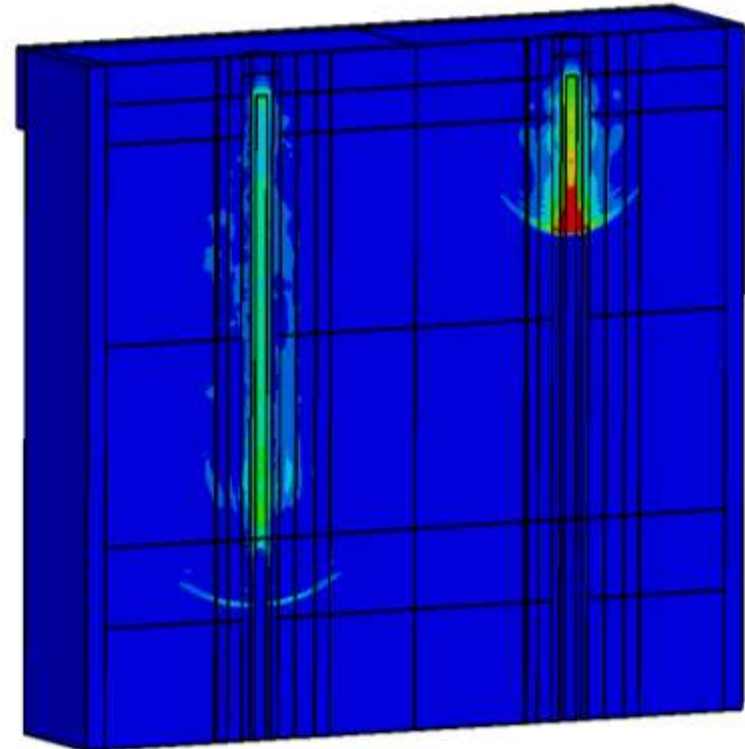


## Calculated pressures

Initiation of first hole



Initiation of second hole





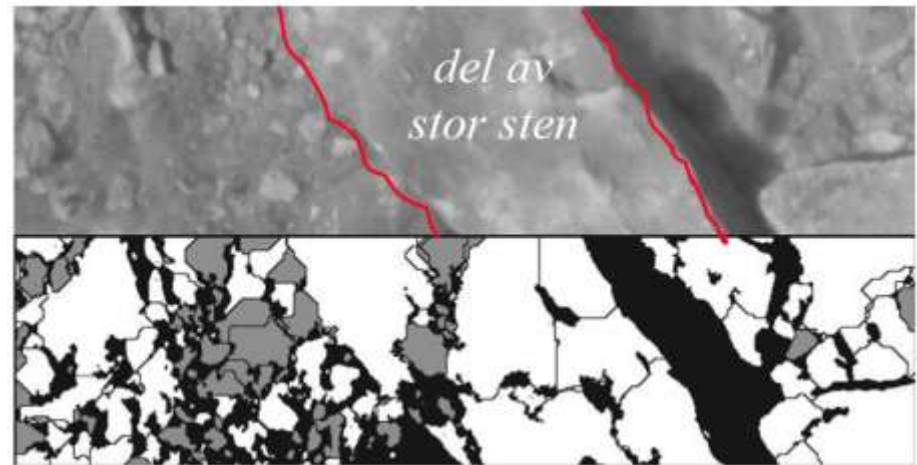
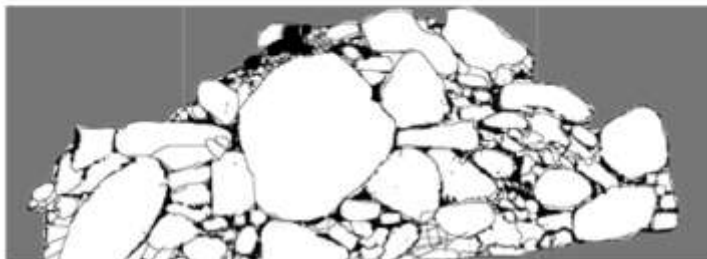
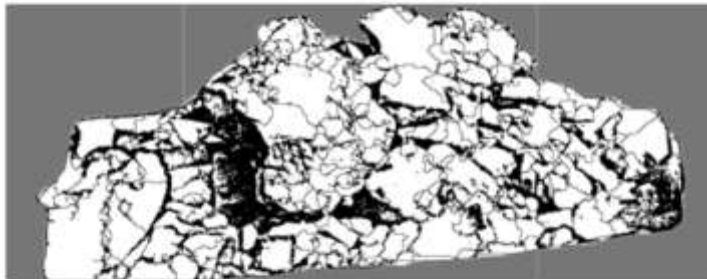
## Full-scale tests at the Aitik open pit

- Reference blasts to determine wave characteristics, etc
- Reference blasts to determine "normal" fragmentation
- Test blasts with different designs
- Follow-up of fragmentation, swell, energy consumption, etc.





## Challenges in measuring fragmentation





## Full-scale tests at the Aitik open pit

- How to measure fragmentation?
  - Improved image processing systems (commercially available today) to be tested
  - Indirectly via energy consumption
  - Sieving is more reliable but impossible in practice





## The way forward...

- Computer simulations
  - Methodology tested and initial simulations: April – Oct, 2011
  - Simulations of model scale tests: May – Dec, 2011
- Field tests at Aitik: May – Oct, 2011
- Open pit blast optimization – 2012
- Sublevel cave blast optimization -- 2012

