Caving in the Fabian Orebody — from Mining Stope to Cave Crater in Malmberget

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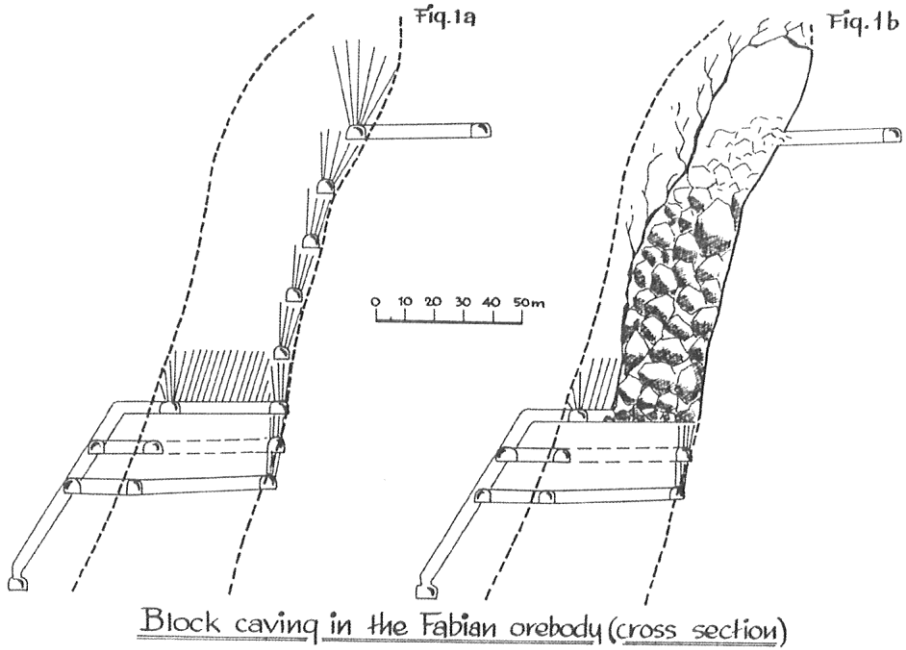
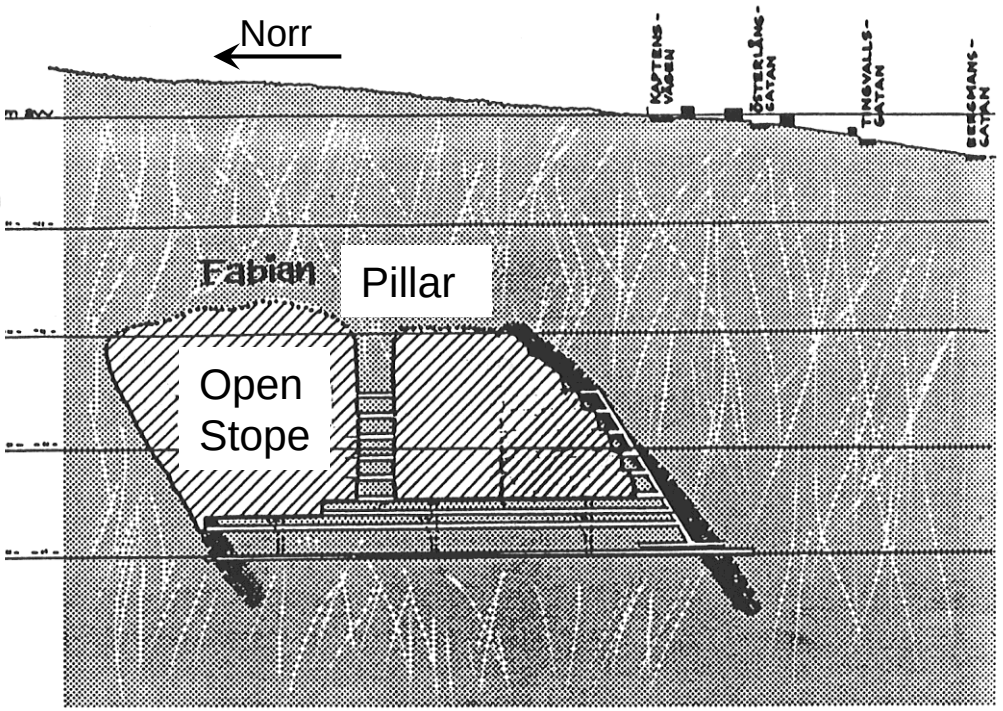
Malmberget and the Fabian Orebody… (year 2010)

Mining in Fabian

- Mining started in 1971 with slot caving
- Sublevel stoping started in 1978
- Large open void after completed stoping and slot caving

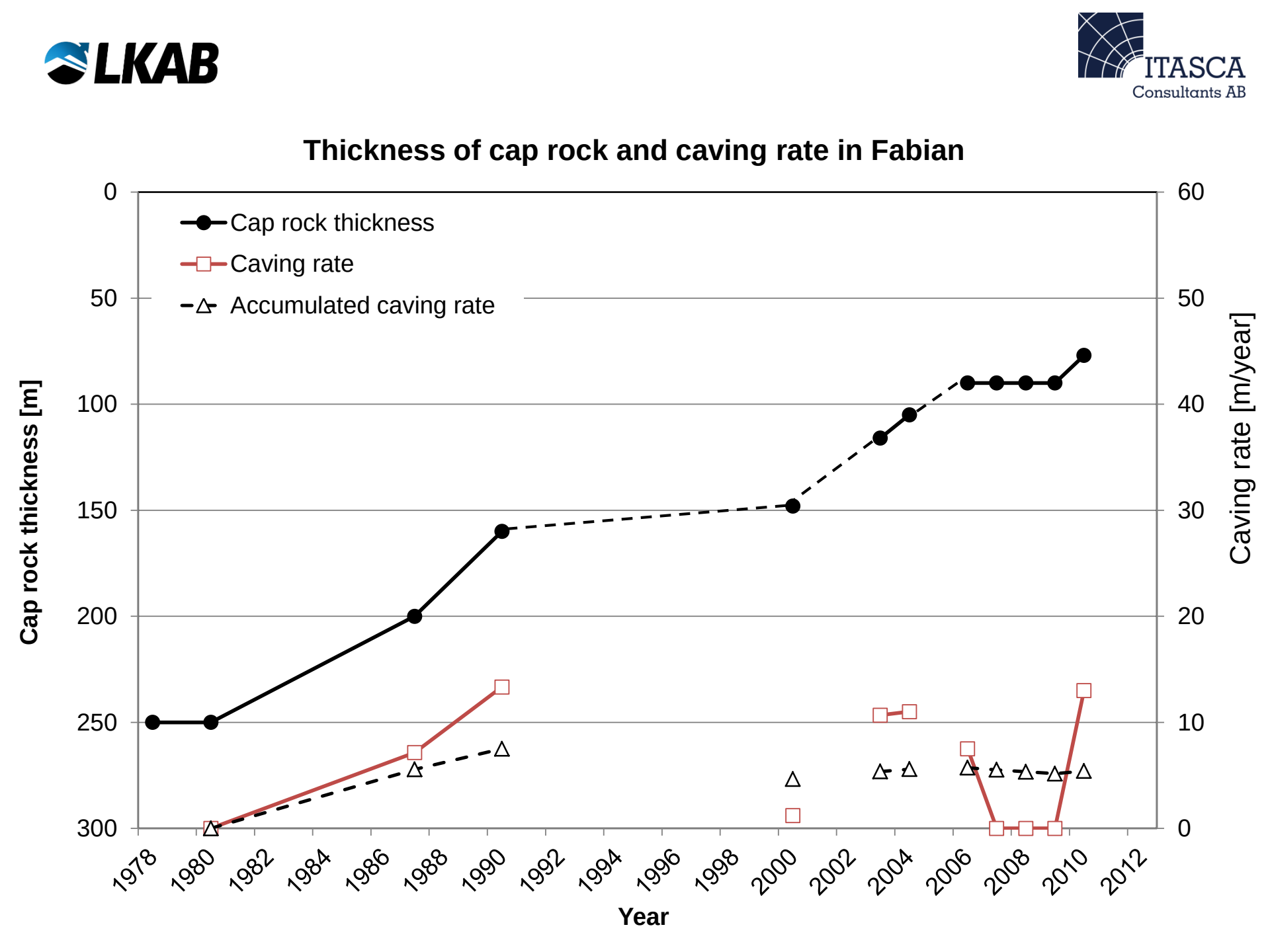


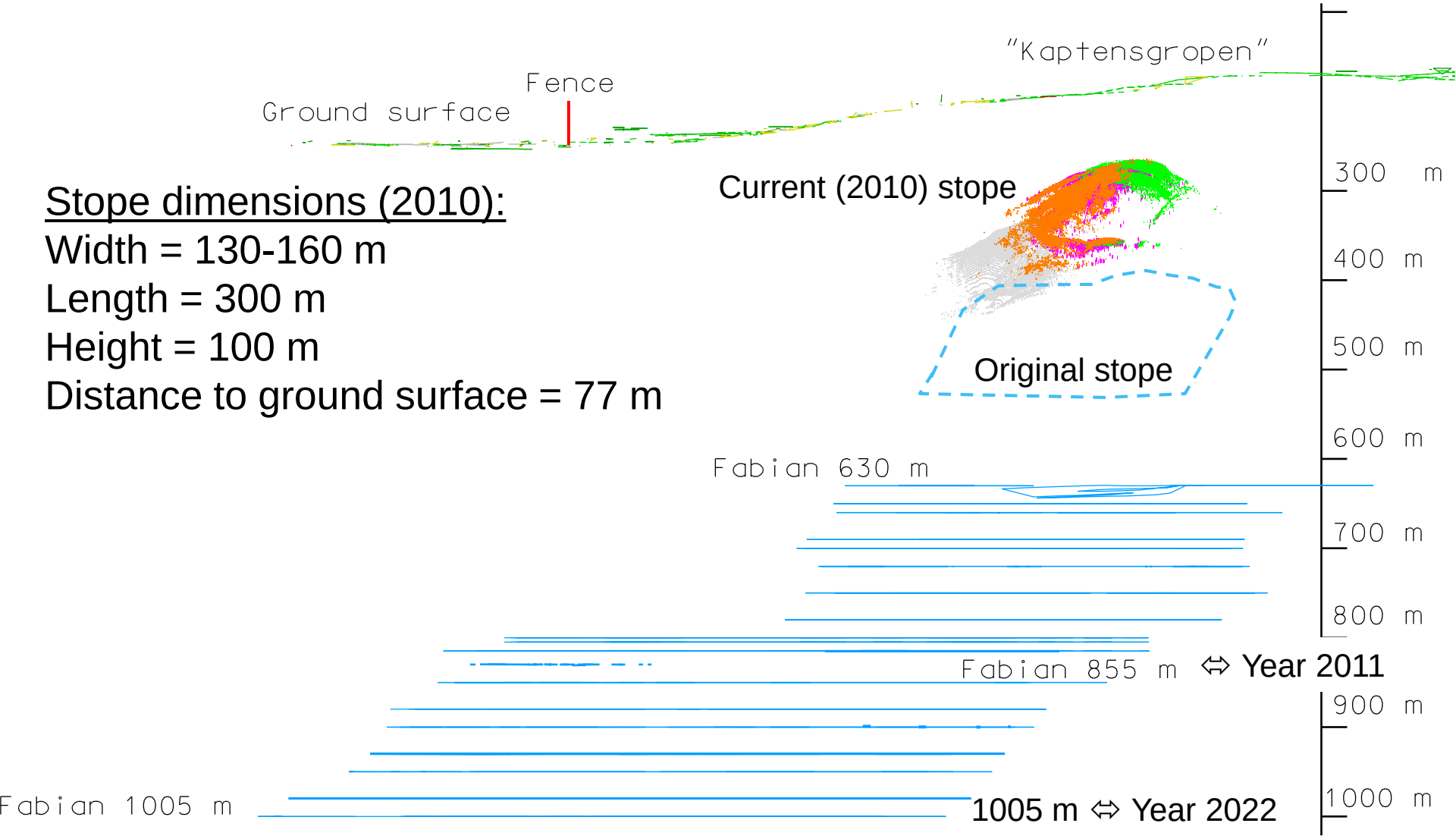
Block caving in the Fabian orebody (cross section)



Mining and Caving 1971 – 2010

- Sublevel cave mining from 548 to 830 m level
- Continuous, slow caving process
- Reduction in cap rock thickness from 250 to 77 m
- Follow-up/monitoring using reflection seismics, probe drilling, laser scanning, etc.
- No ground deformations on surface above the stope


Thickness of cap rock and caving rate in Fabian
Cap rock thickness
Caving rate
Accumulated caving rate
Cap rock thickness [m]
Caving rate [m/year]
Year
0
50
100
150
200
250
300
60
50
40
30
20
10
0
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012



Stope dimensions (2010):

Width = 130-160 m

Length = 300 m

Height = 100 m

Distance to ground surface = 77 m

Prognosis 2010

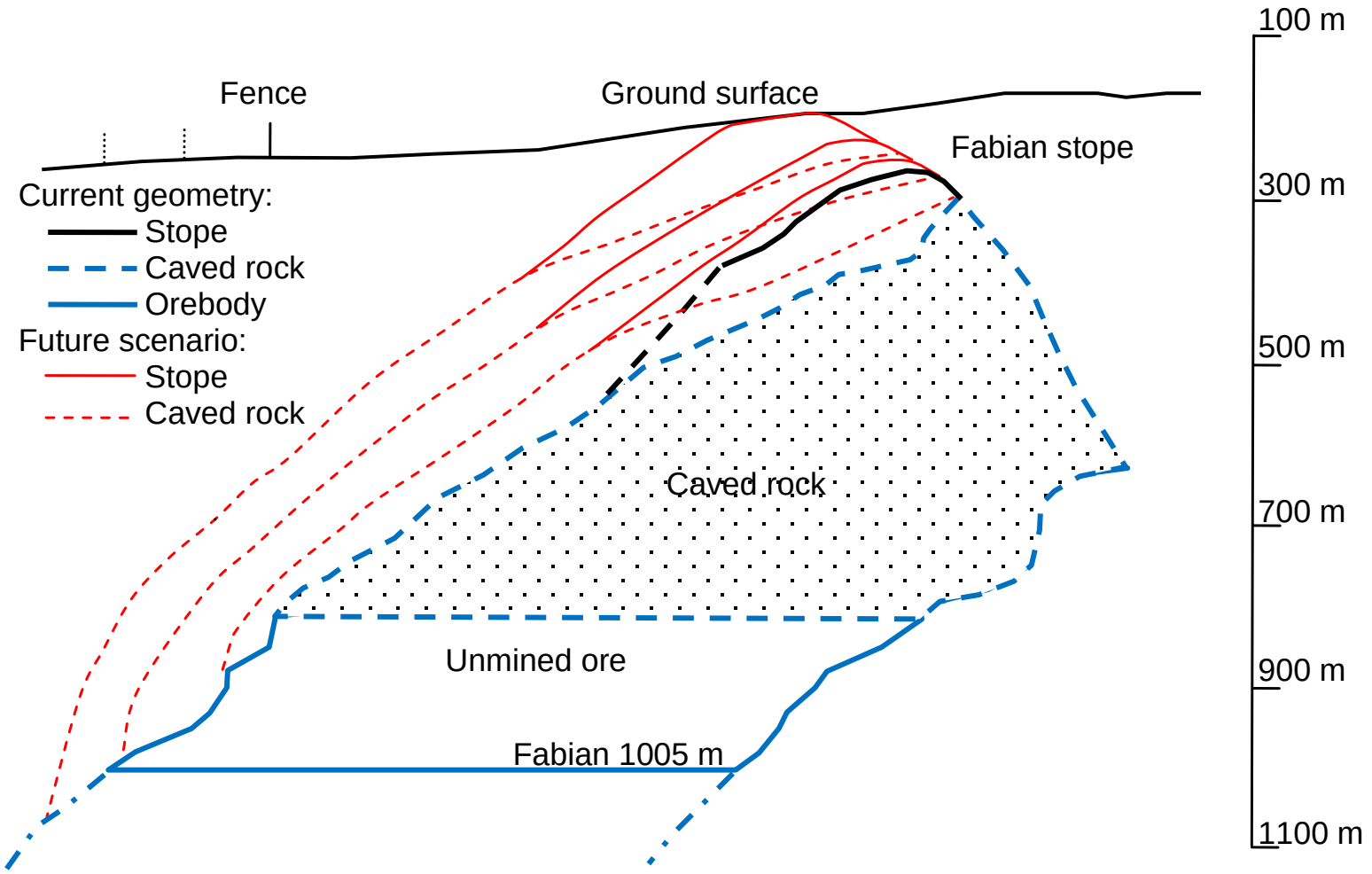
- Compilation of existing material / data
- Scenario description (prognosis) as basis for action plan in case of collapse
- Three scenarios:
  - Stable cap rock / crown pillar => low likelihood
  - Gradual caving => high likelihood
  - Sudden collapse => low likelihood
- Action plan
  - Monitoring
  - Activity plan for different scenarios

Most likely scenario…

- **Slow caving/expansion of void, toward the Kapten cave crater, gradual caving of cap rock**
  - Likelihood: High
  - Consequences: Small vibrations and noise on ground surface
    Small seismic events
    Gradual expansion of Kapten cave crater
    Some dusting in the area
    No consequences outside the fence

Scenario description

Caving and expansion of Fabian stope



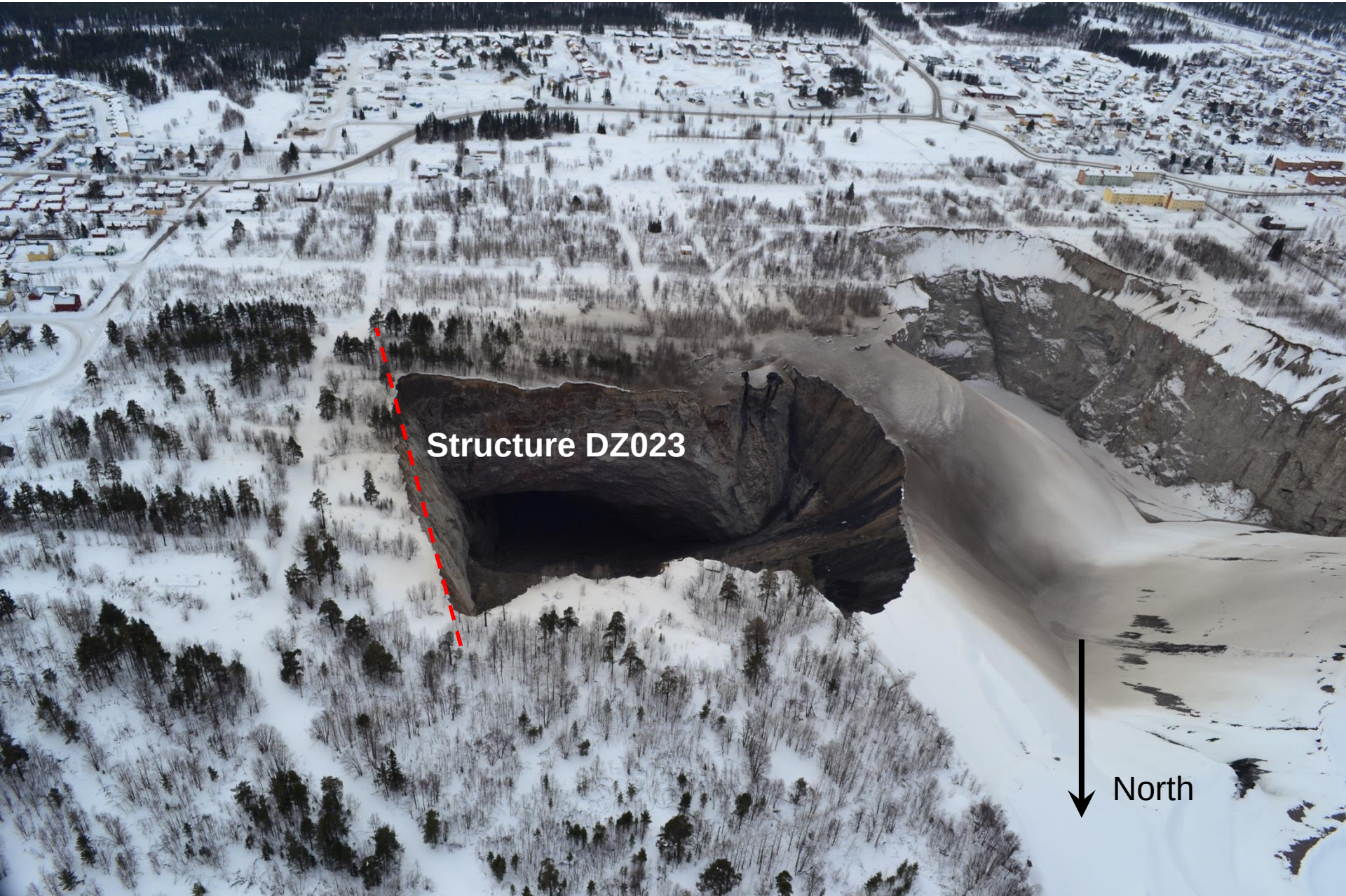
Scenario Description

What happened?

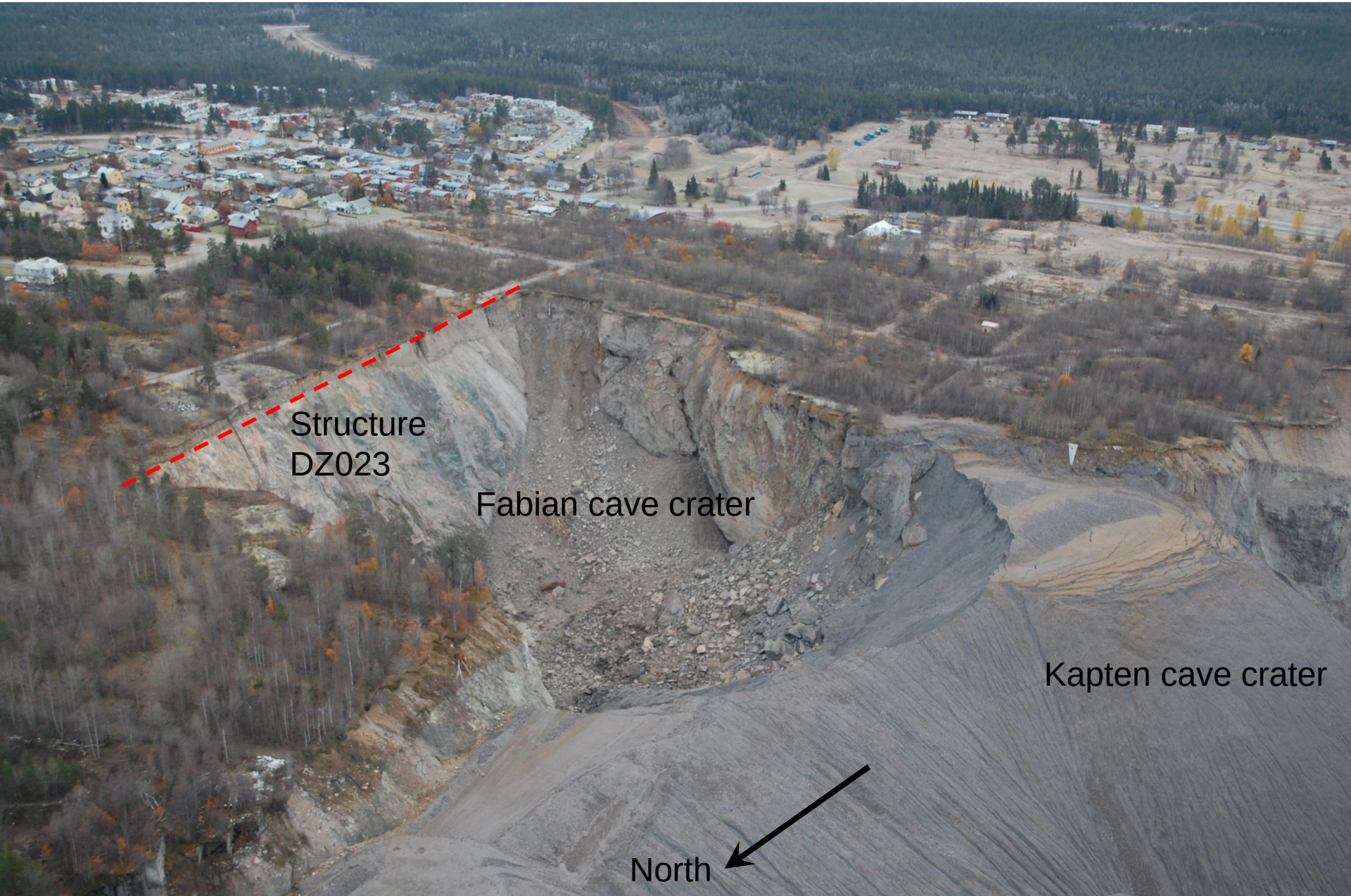
- Gradual caving during 2011–2012
  - May, 2011: 55 m cap rock
  - Jan, 2012: 41 m cap rock
    (no more scanning performed due to safety)
  - March 2012: Increase in seismic activity
- March 20, 2012:
  - Breakthrough to ground surface, new cave crater
  - Slow event, little dusting
  - Slight expansion the following days, stable thereafter

March 20, 2012

March 21, 2012



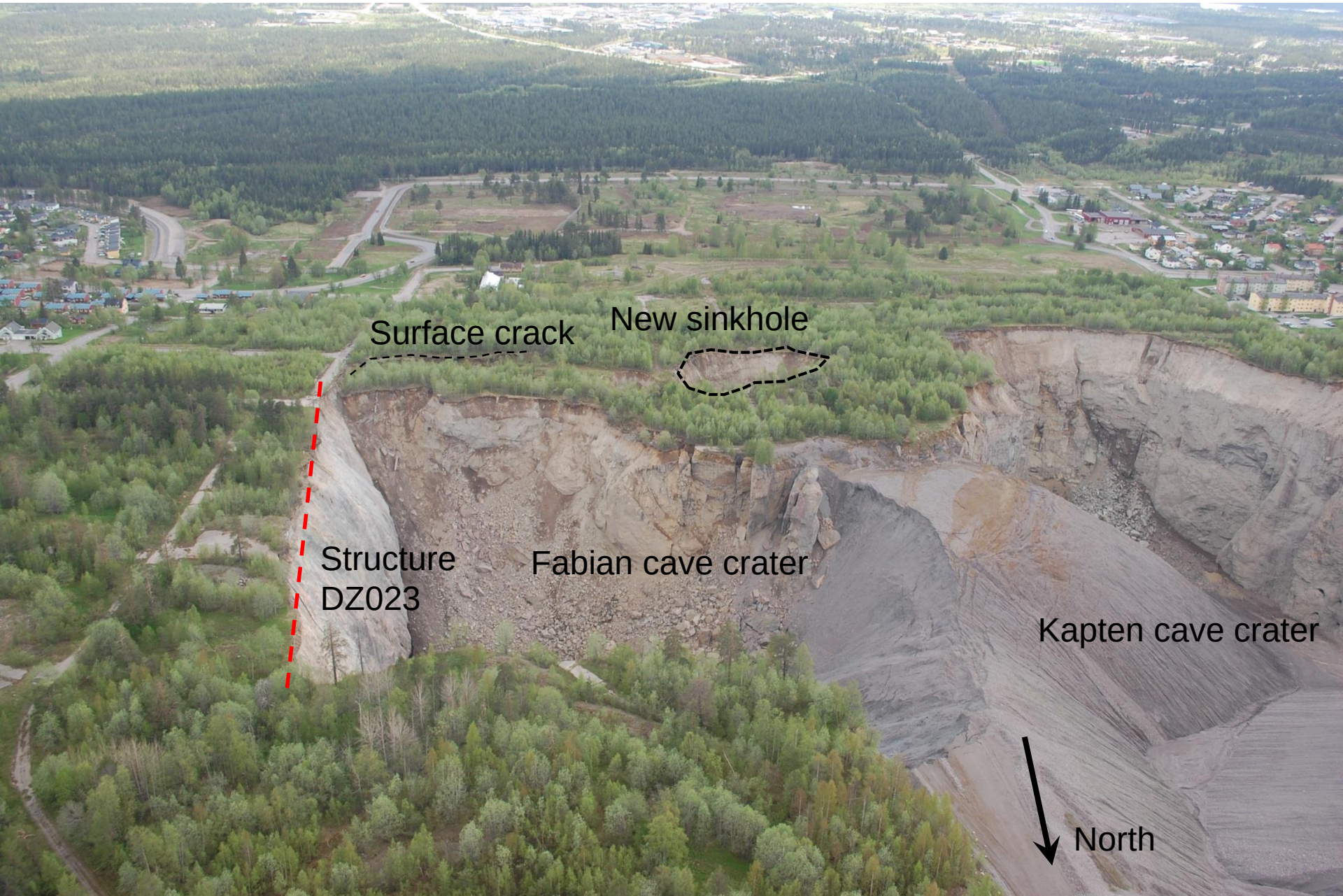
October 22, 2012

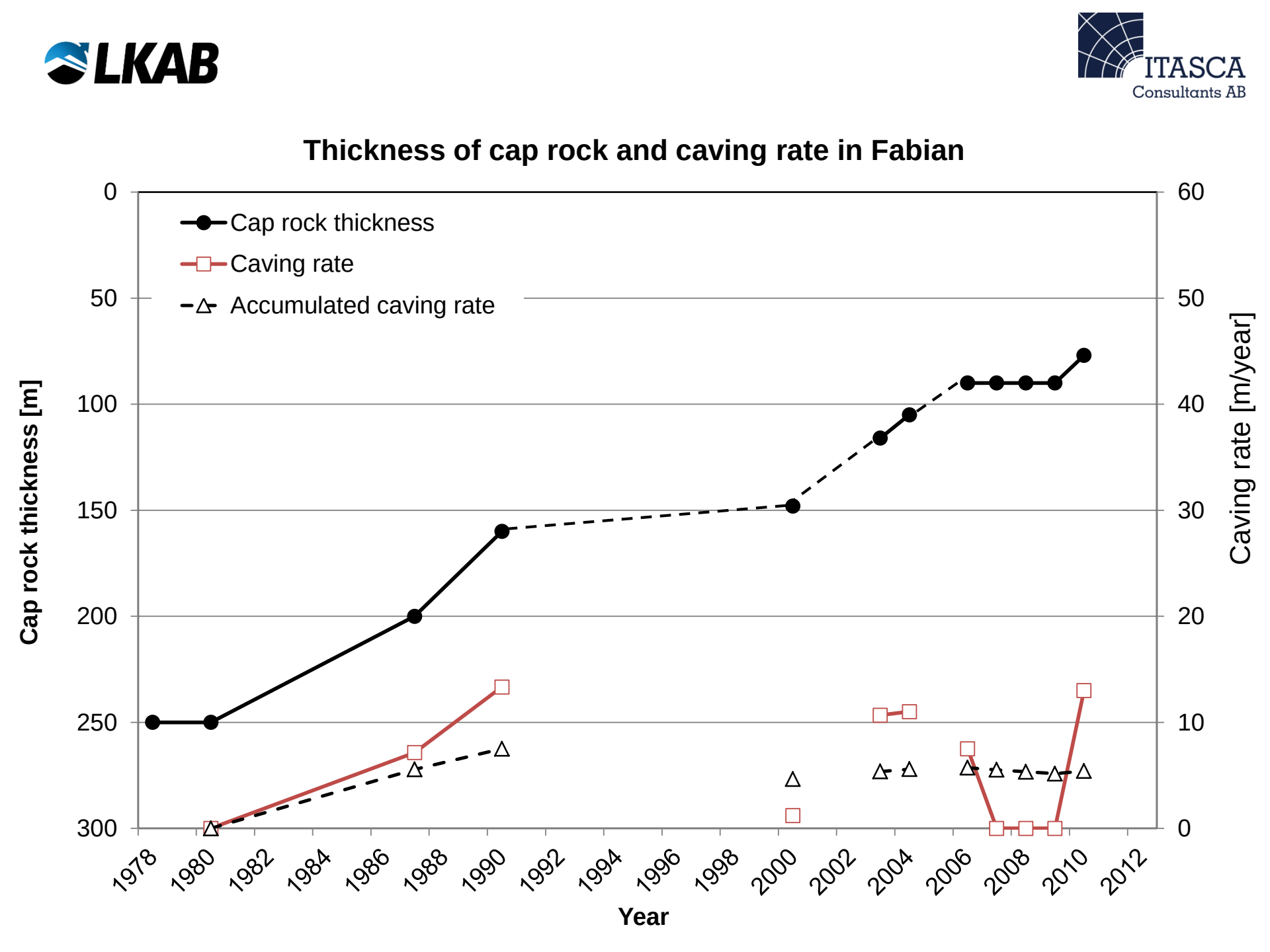


September 25, 2013

March 26, 2014

June 3, 2014


Surface crack
New sinkhole
Structure
DZ023
Fabian cave crater
Kapten cave crater
North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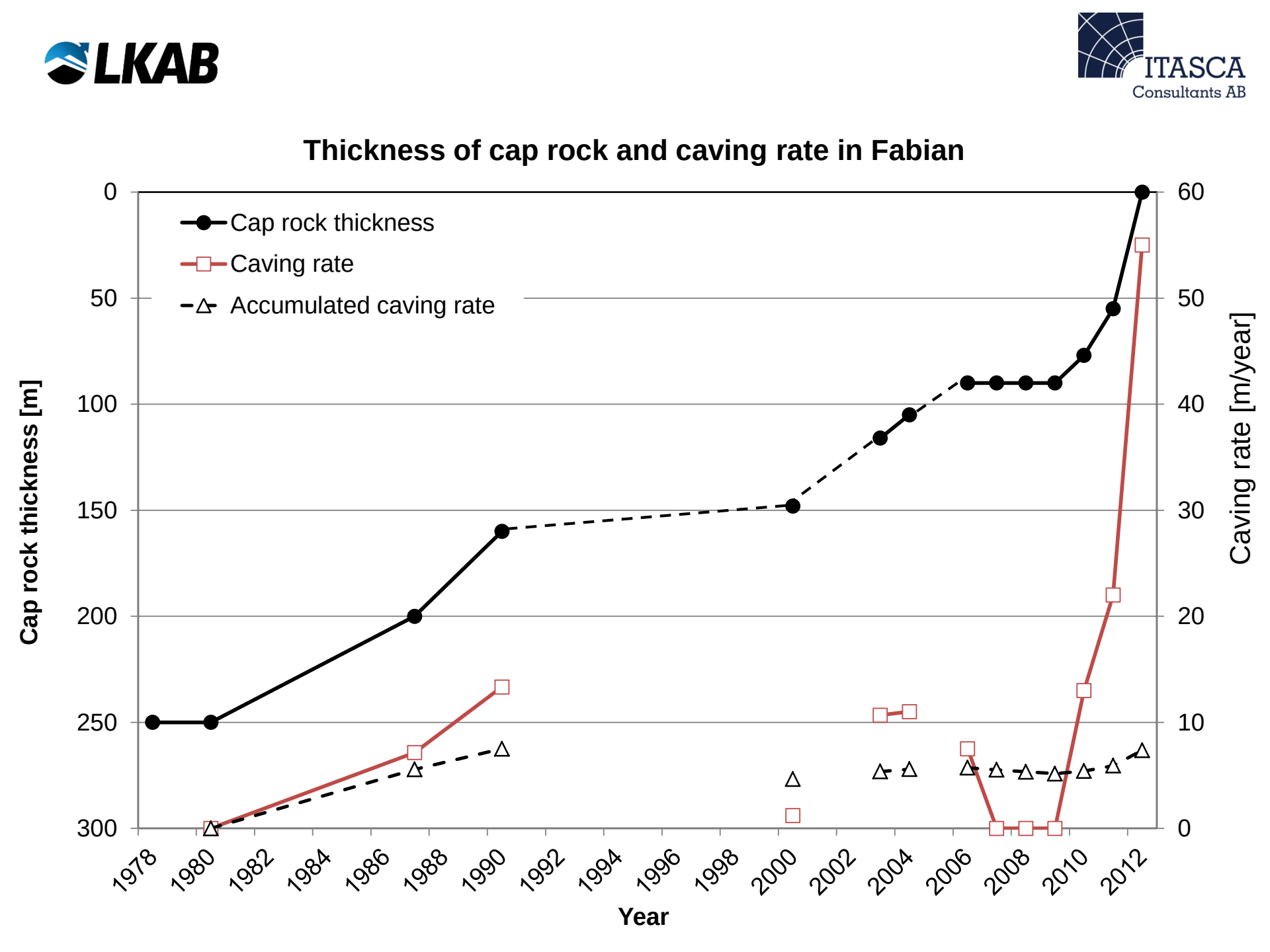
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Conclusions & Further Work (I)

- Prognosis based on existing data, empirical relations and engineering judgement was found to be very ***reliable***!
- Cave development, location and shape of new cave crater agreed well with prognosis
- Smooth caving process resulting in minimal disturbance to the municipality and the public.
- Numerical modeling could not replicate all aspects of the cave process

Conclusions & Further Work (II)

- Follow-up of ground deformations through systematic measurements
- Criterion for allowable mining-induced ground deformations proposed
- Knowledge increase required:
  - Caving process in cap rock / crown pillar / non-daylighting orebodies
  - Numerical modeling of caving / cave mining

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Reference group: Jan-Olof Hedström / Åsa Persson (Mining Inspectorate)
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