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Geological Survey
of Northern Ireland

Institute of Geologists of Ireland

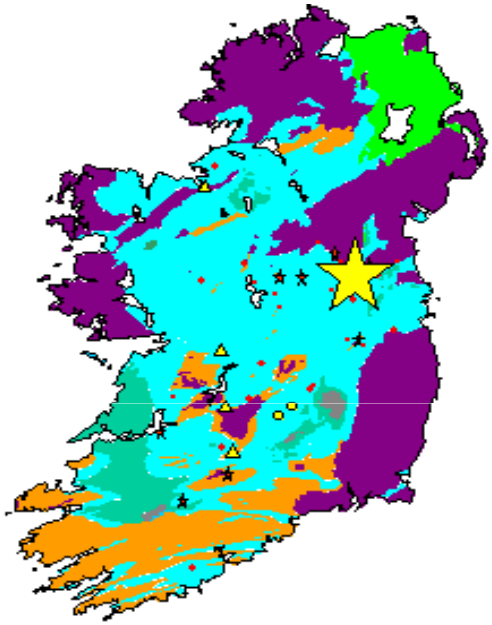
2006 Conference

‘Developing Our Assets’

Exploration in Ireland – the Future?

IGI Annual Conference, Dublin Castle 15th November, 2006

J.H.Ashton - Boliden Tara Mines Limited



Irish Carbonate Hosted Deposits

Good Exploration Targets, because:

- High success rate per km^2 in exploration, relative to other countries
- Very localized high grade Zn/Pb (+/- Ag, Ba, Cu), easy to mine
- Metallurgically simple, clean Zn concentrates
- Excellent geotechnical conditions and productive stoping
- Near European smelters
- Excellent infrastructure
- State incentives for exploration, including tax, availability of data etc
- In European terms, Ireland is ‘mining + explorer friendly’

Drawbacks:

- Very sensitive to low Zn/Pb price, lack of ‘other’ credits
- Celtic-Tiger environment, industrial relations, high costs, urbanisation
- Mining has a poor public perception in Ireland
- Environmental, Planning and Mining Licensing are time consuming

Irish Zn/Pb Mining Today

Today, in 2006, the Irish Base Metal Mining Industry is a massive success:

- Major source of European base metals
- Highly profitable operations for respective companies (currently)
- Supplying ~1300 direct, well paid, highly trained jobs
- Supplying a further indirect employment of ?~3000?
- Major injection of wealth to local communities and Ireland

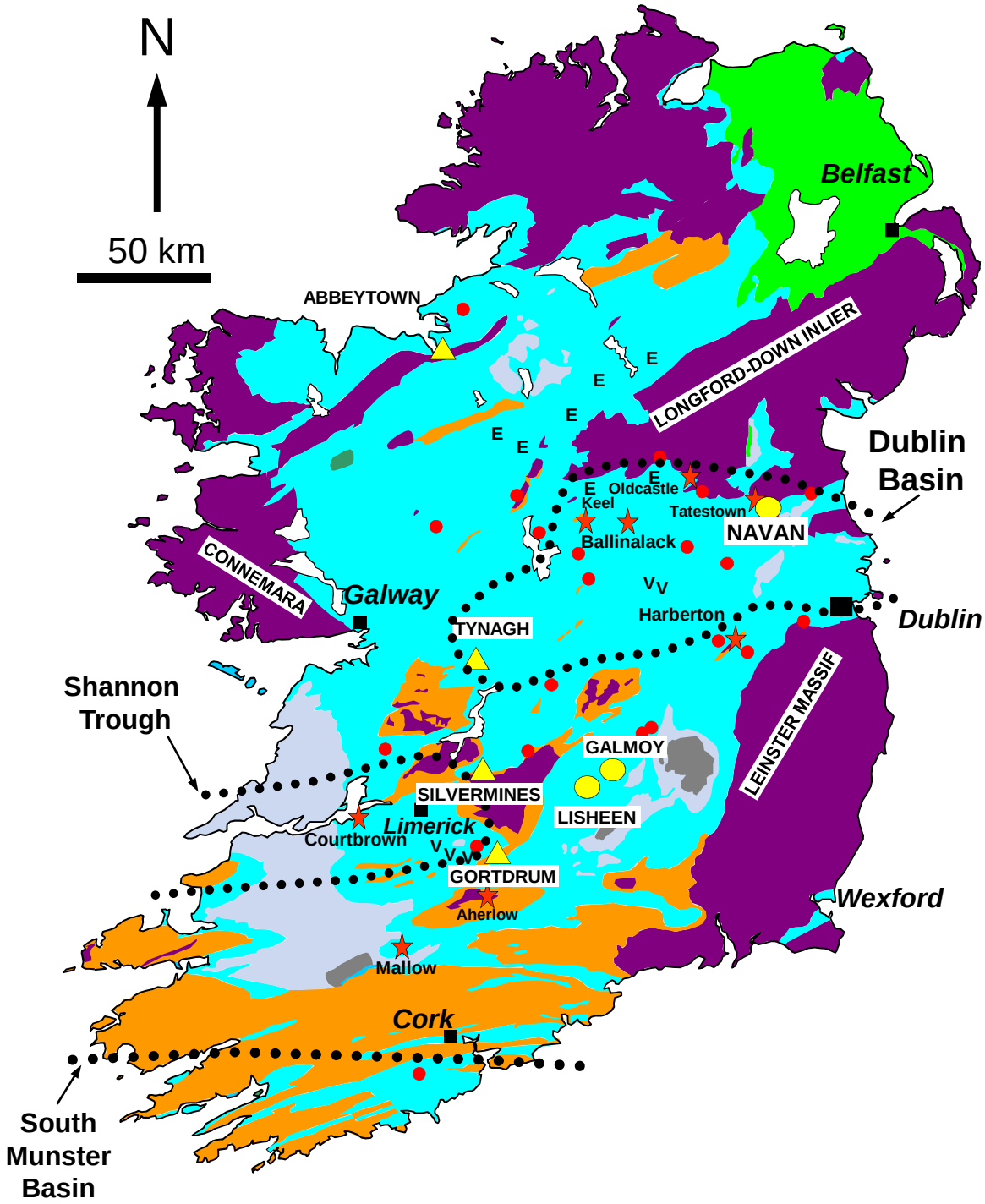
BUT

The three current operations have finite lengths, dependant on:

- Depletion rates and reserves
- Replenishment of reserves: near-mine exploration additions
- Marginal ore, new technology
- Metal prices
- Operating costs

Do we want to be mining in 10 years ?

If so, New Orebodies MUST be found



Carboniferous Carbonate-Hosted Deposits

- ● - Mine (Active)
- △ - Mine (Closed)
- ★ - Major Prospect
- ● - Minor Prospect
- V - Lwr. Carboniferous Volcanics
- E - Lwr. Carboniferous Evaporites

- Post Carboniferous
- Westphalian
- Namurian
- Dinantian (Mississippian)

Carboniferous

- Devonian
- Pre - Devonian

Historical Exploration - Summary

1960-1970: Tynagh – Silvermines – Gortdrum – Navan (Near Surface->Shallow)
High element of shallow soil geochemistry, induced polarisation geophysics preceding diamond drilling but locally important:

- Stream sediment geochemistry (Gortdrum, Navan)
- Historical mining (Silvermines)
- Mineral in outcrop/float (Navan)

1980-1990: Galmoy – Lisheen (Buried)
Shallow soil geochemistry but greater geophysics contribution (particularly IP)
More emphasis on geologically directed diamond drilling

1990-2006: Significant Extensions to Navan, Galmoy and Lisheen (Deeper)
Continuing increased emphasis on diamond drilling and geophysics (gravity)

Massive but unsuccessful exploration expenditure on Airborne Geophysics

Historical Exploration - Comment

Most discoveries by junior/small companies NOT by multinationals.

Companies (+entrepreneurs) took large financial risks for discoveries,
Many were unsuccessful.

Exploration successes were anything but easy, virtually all had elements of good fortune, persistence, intelligent observation and hard effort (+ very little high-tech).

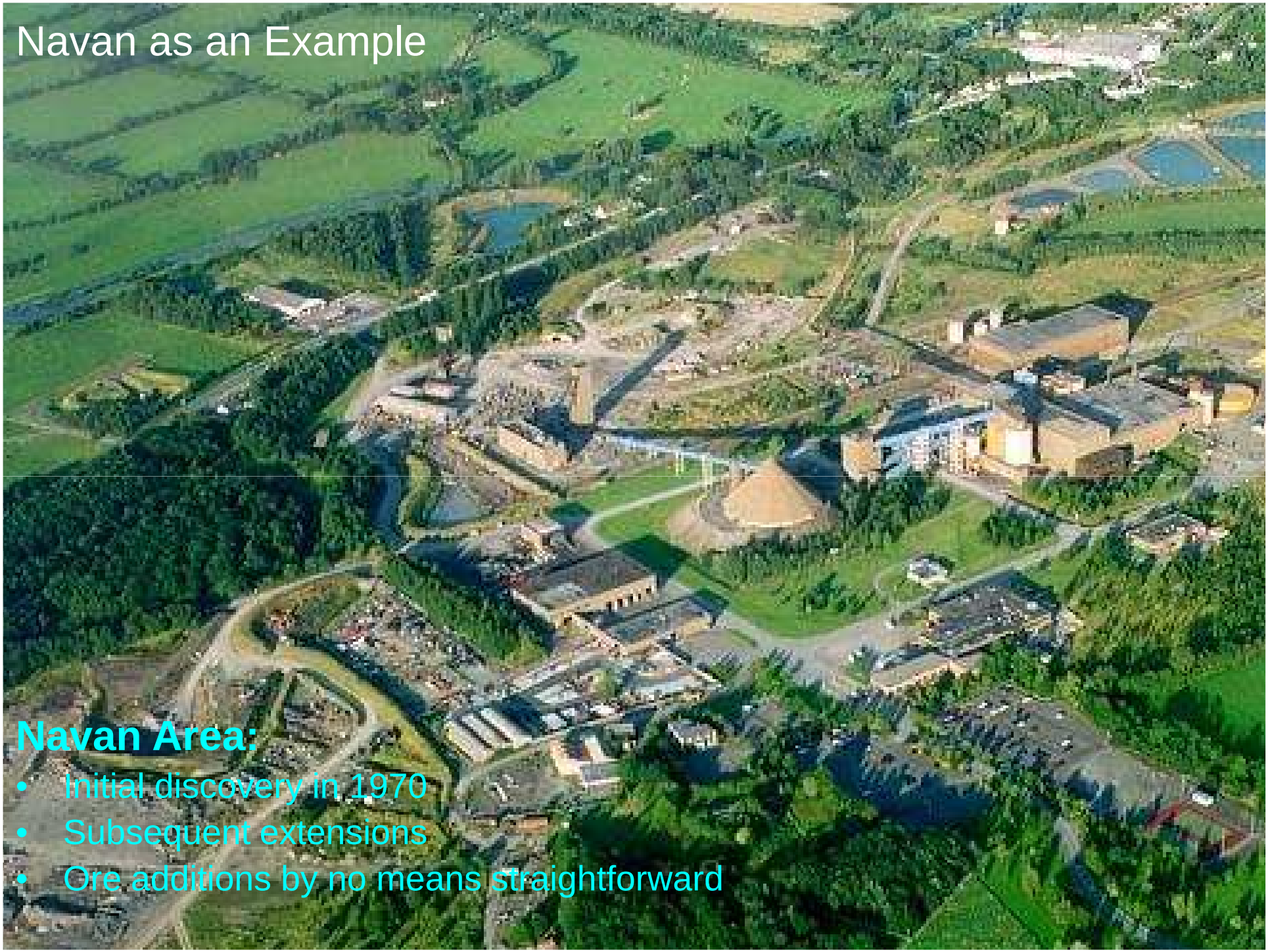
Useful concept (only) 1000 anomalies > 100 targets > 10 prospects > 1 mine

Exploration is a NOT a straightforward scientific investigative process there are a host of other factors involved in finding a mine – it is by no means an exact science but it is most certainly an exceptionally high-risk business!

Timing, technical management, confidence, funding, persistence and luck!

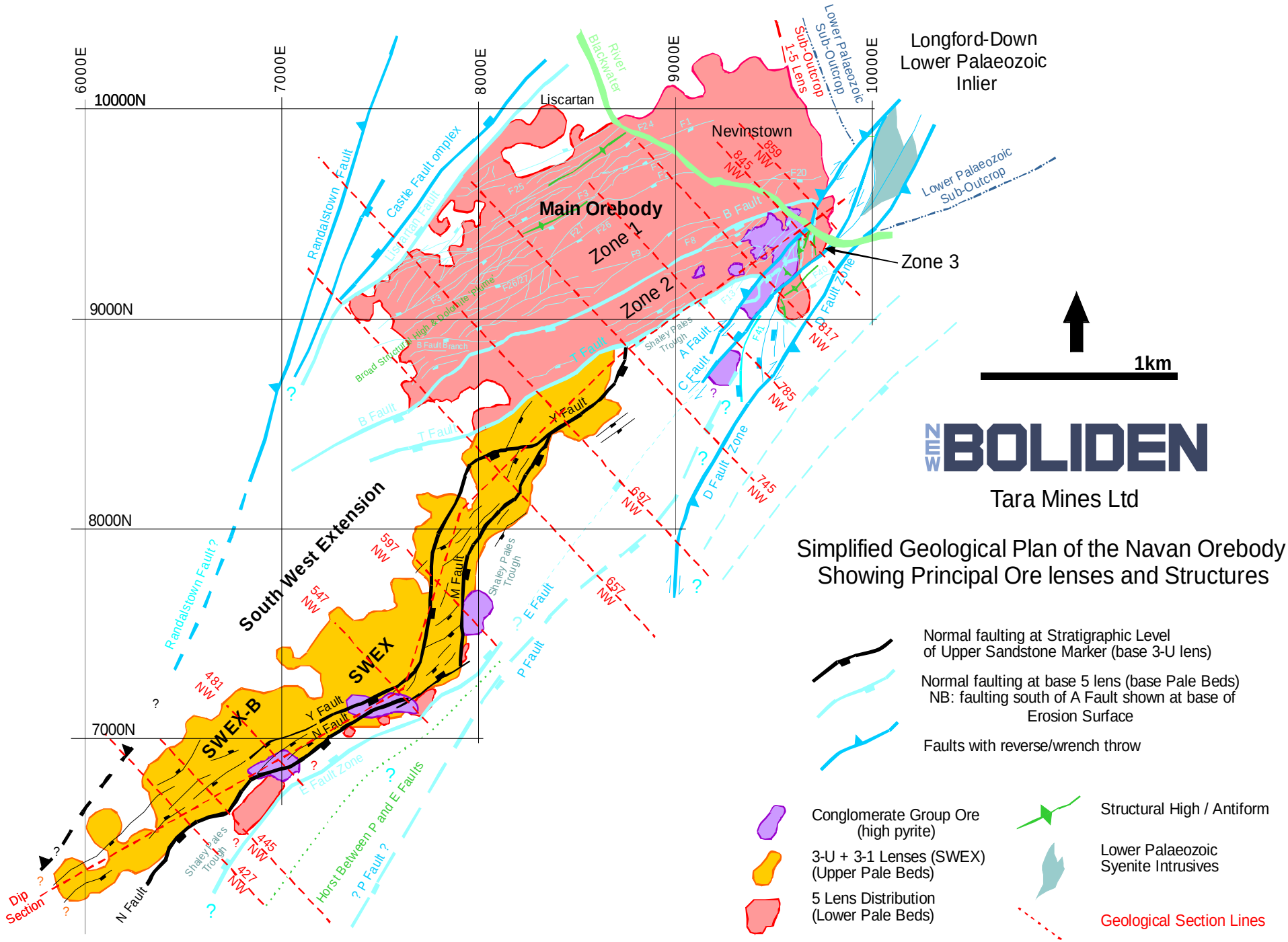
Highly regimented and costly Airborne Geophysical emphasis of last decade – was it a waste?, how useful is the data and could interpretetion be improved?

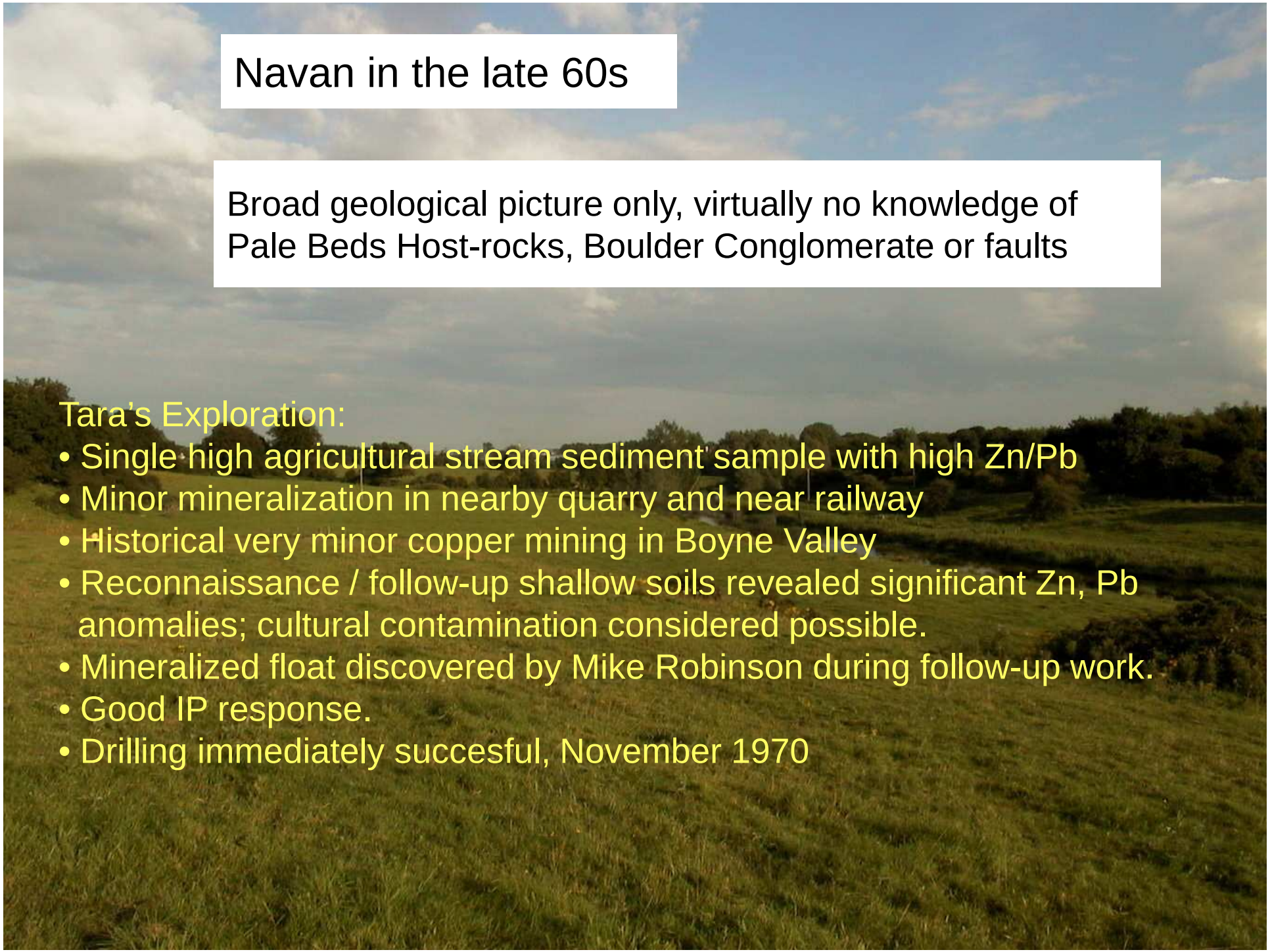
Navan as an Example



Navan Area:

- Initial discovery in 1970
- Subsequent extensions
- Ore additions by no means straightforward


6000E
7000E
8000E
9000E
10000E
10000N
9000N
8000N
7000N
Longford-Down
Lower Palaeozoic
Inlier
Liscartan
Nevinstown
Main Orebody
Zone 1
Zone 2
Zone 3
Randalstown Fault
Castle Fault omplex
Liscartan Fault
River Blackwater
Lower Palaeozoic Sub-Outcrop
1-5 Lens Sub-Outcrop
B Fault
T Fault
A Fault
C Fault
D Fault Zone
P Fault Zone
Broad Stratiform High & Dolomite Plume
Shaley Pales Trough
South West Extension
SWEX
SWEX-B
M Fault
Y Fault
N Fault
E Fault
P Fault
E Fault Zone
Horst Between P and E Faults
P Fault ?
Randalstown Fault ?
Dip Section
1km
NEW BOLIDEN
Tara Mines Ltd
Simplified Geological Plan of the Navan Orebody
Showing Principal Ore lenses and Structures
Normal faulting at Stratigraphic Level
of Upper Sandstone Marker (base 3-U lens)
Normal faulting at base 5 lens (base Pale Beds)
NB: faulting south of A Fault shown at base of
Erosion Surface
Faults with reverse/wrench throw
Conglomerate Group Ore
(high pyrite)
3-U + 3-1 Lenses (SWEX)
(Upper Pale Beds)
5 Lens Distribution
(Lower Pale Beds)
Structural High / Antiform
Lower Palaeozoic
Syenite Intrusives
Geological Section Lines



Navan in the late 60s

Broad geological picture only, virtually no knowledge of Pale Beds Host-rocks, Boulder Conglomerate or faults

Tara's Exploration:

- Single high agricultural stream sediment sample with high Zn/Pb
- Minor mineralization in nearby quarry and near railway
- Historical very minor copper mining in Boyne Valley
- Reconnaissance / follow-up shallow soils revealed significant Zn, Pb anomalies; cultural contamination considered possible.
- Mineralized float discovered by Mike Robinson during follow-up work.
- Good IP response.
- Drilling immediately succesful, November 1970

Navan Discovery - Comment

Historically - How on earth did such a huge orebody remain undiscovered so close to Navan Town ?

Previous Licence holder had ignored the anomaly.

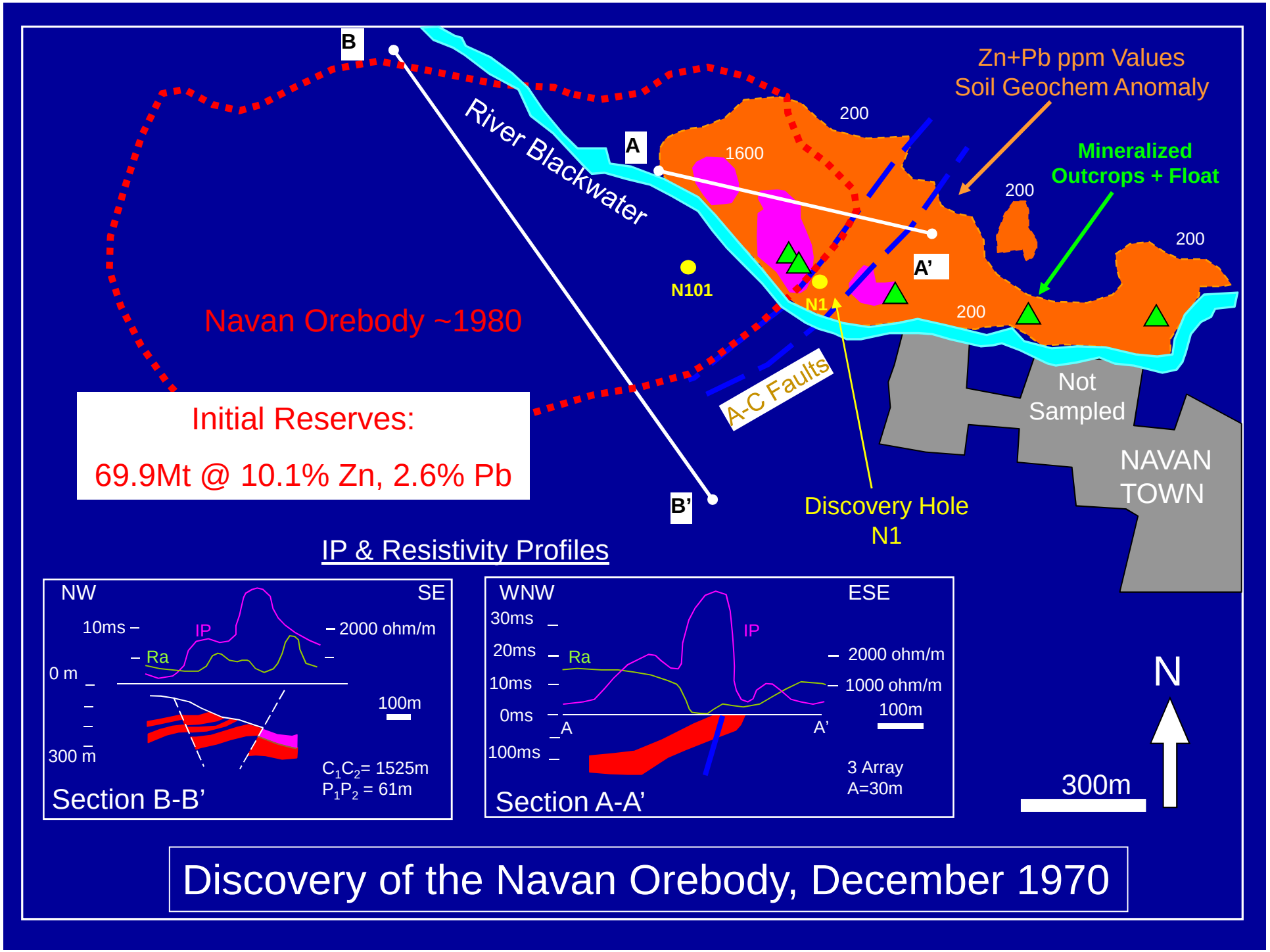
2nd and 3rd drill holes were poor and stepped away from ore. Because of the smear of the anomaly downstream along the Blackwater it's possible that alternative hole locations to N1 could have missed!

The first 3 holes sited on a marginal area – still not mined today!

Main delineation and scout drilling phase that followed missed several areas of ore and the next major extension was not until the early 90s.

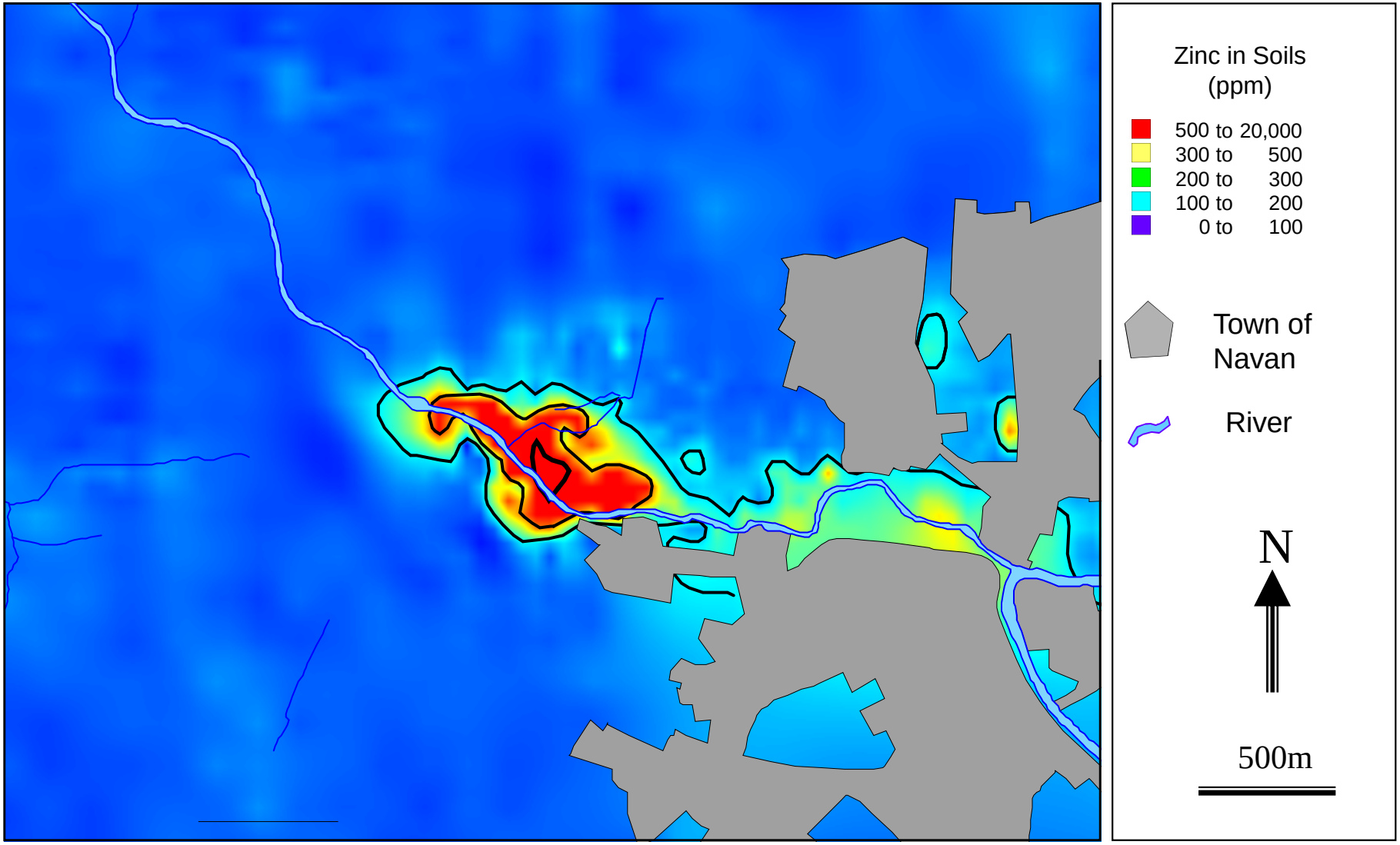
No evidence that the bulk of the orebody was SW of the Blackwater.

Size CAN be a problem!

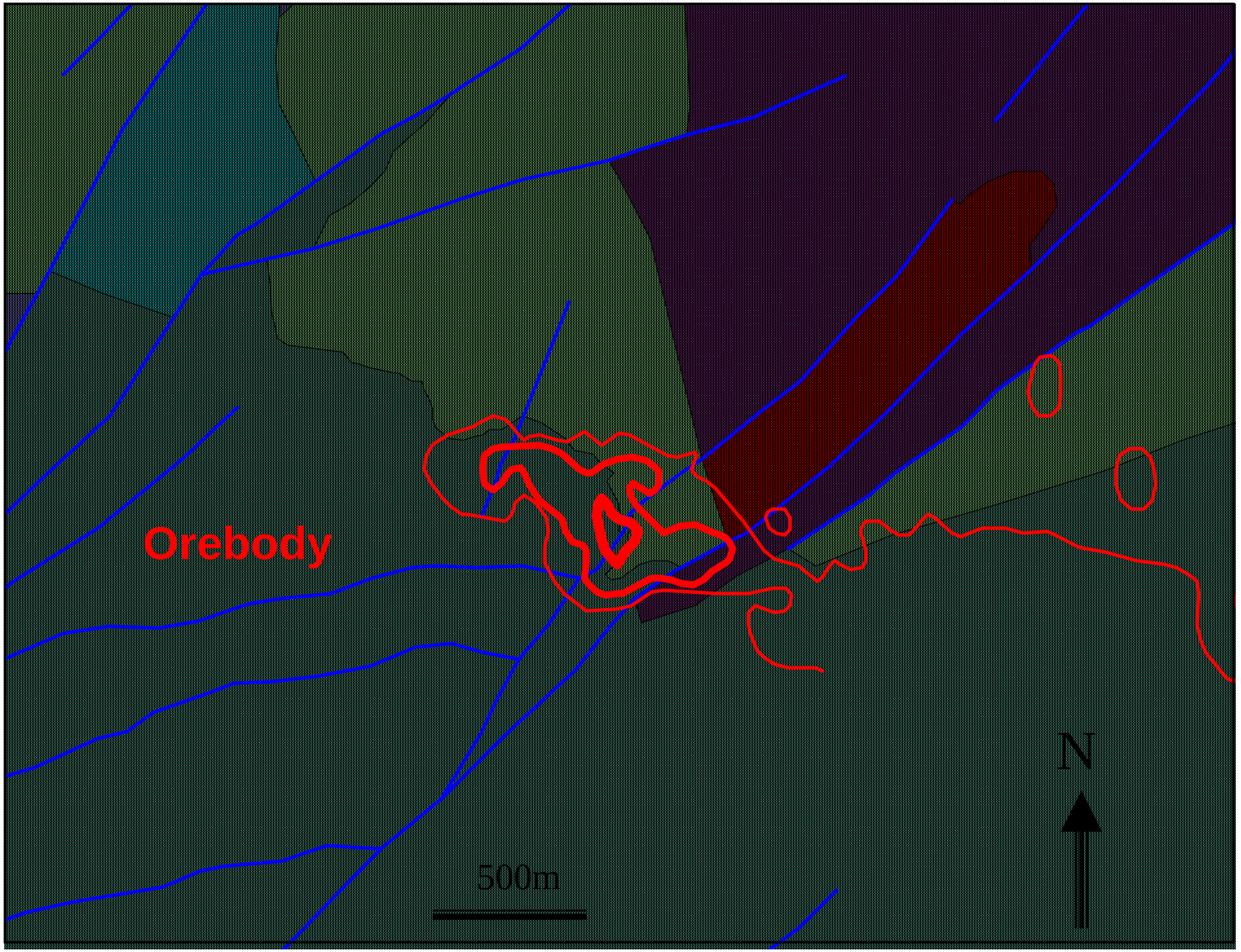


Discovery of the Navan Orebody, December 1970

Tara Soil Geochemistry



Orebody Outline



Bedrock Legend

- Upper Dark Limestone
- Waulsortian Limestone
- Argillaceous Bioclastic Limestone
- Navan Group Beds
- Lower Palaeozoic
- Felsic Intrusive
- Fault
- Orebody outline

Depth of Mineralization

- 5m
- 25m
- 50m
- 100m
- 200m
- >400m

Anomalous Geochemistry

- >200ppm Zn
- >500ppm Zn
- >2300ppm Zn

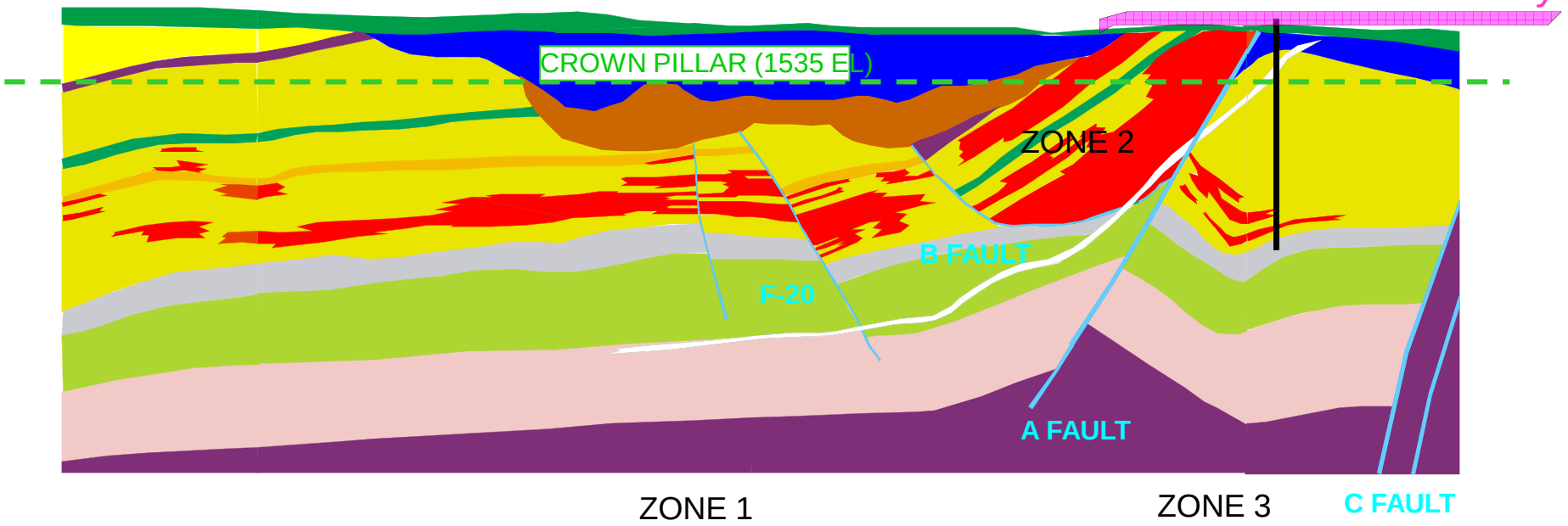
NW

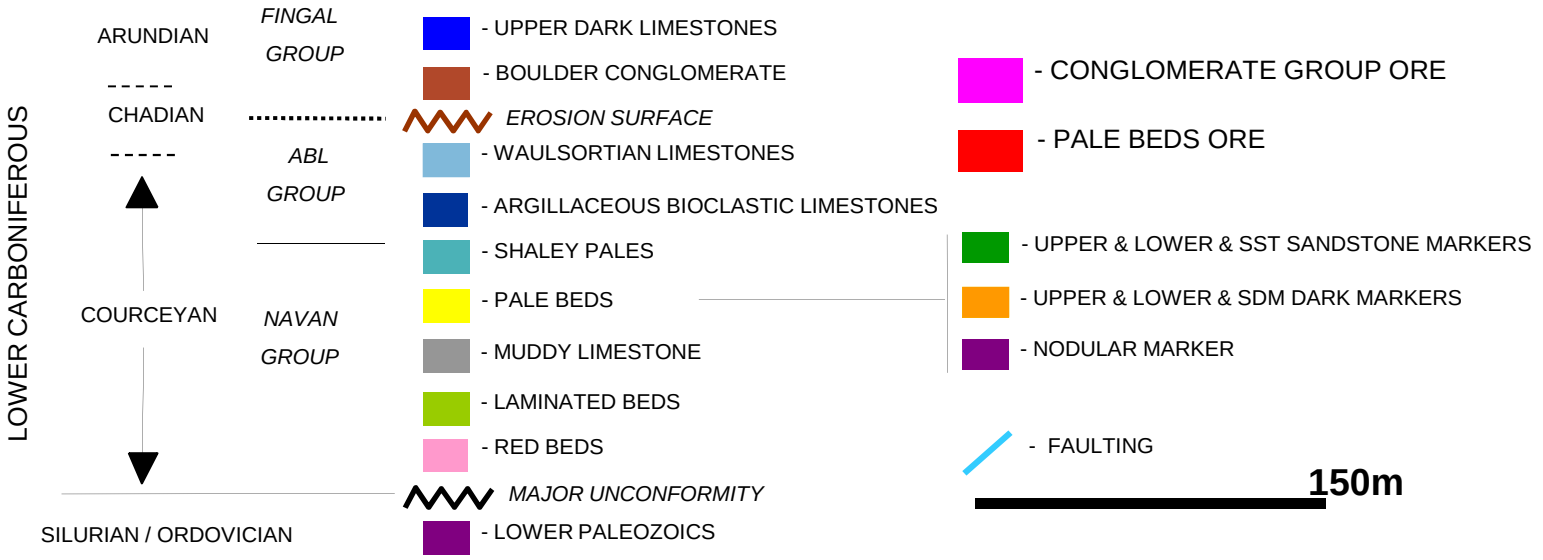
NW SECTION 859NW - NEVINSTOWN

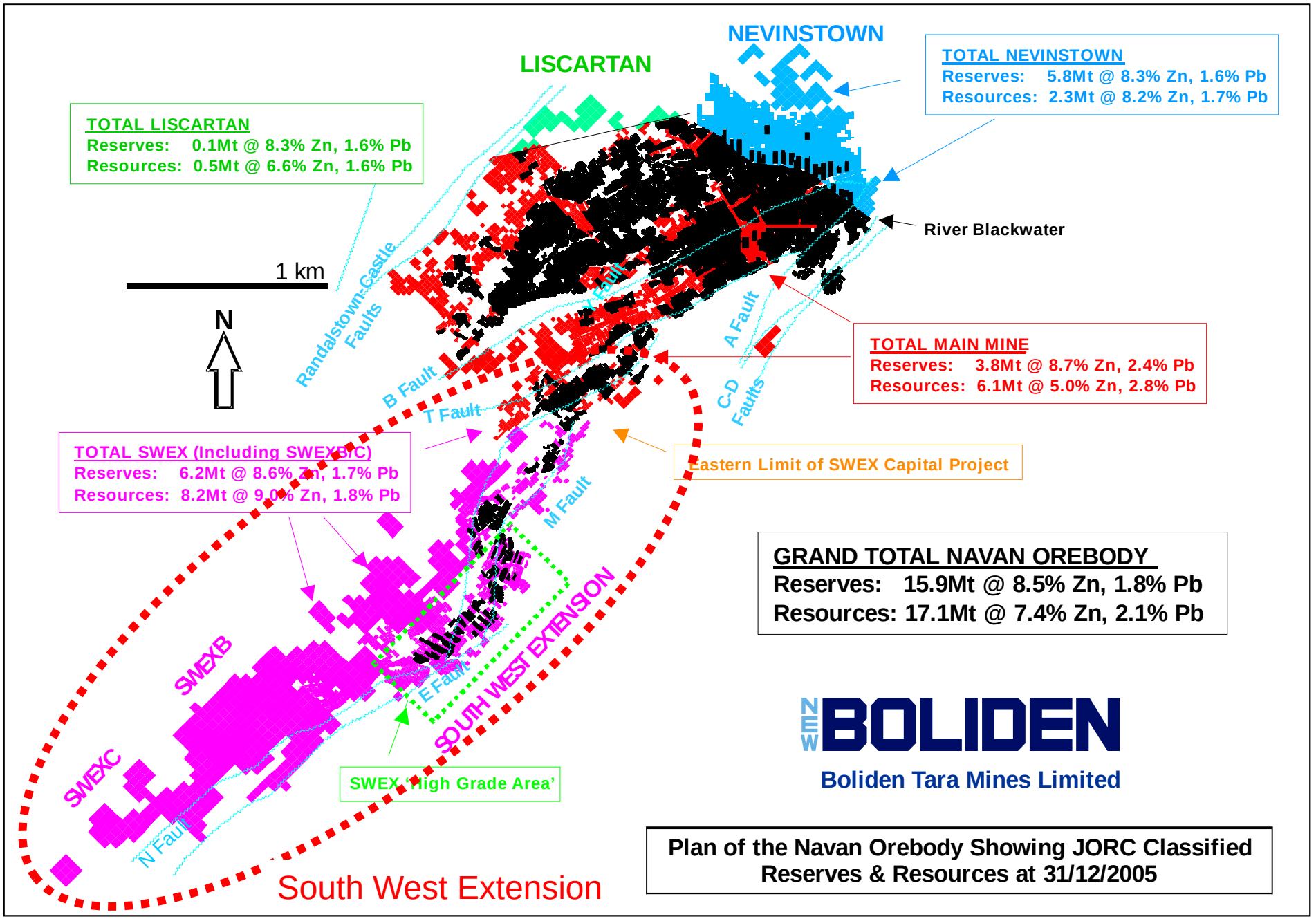
Discovery Hole N1

SE

Soil Anomaly



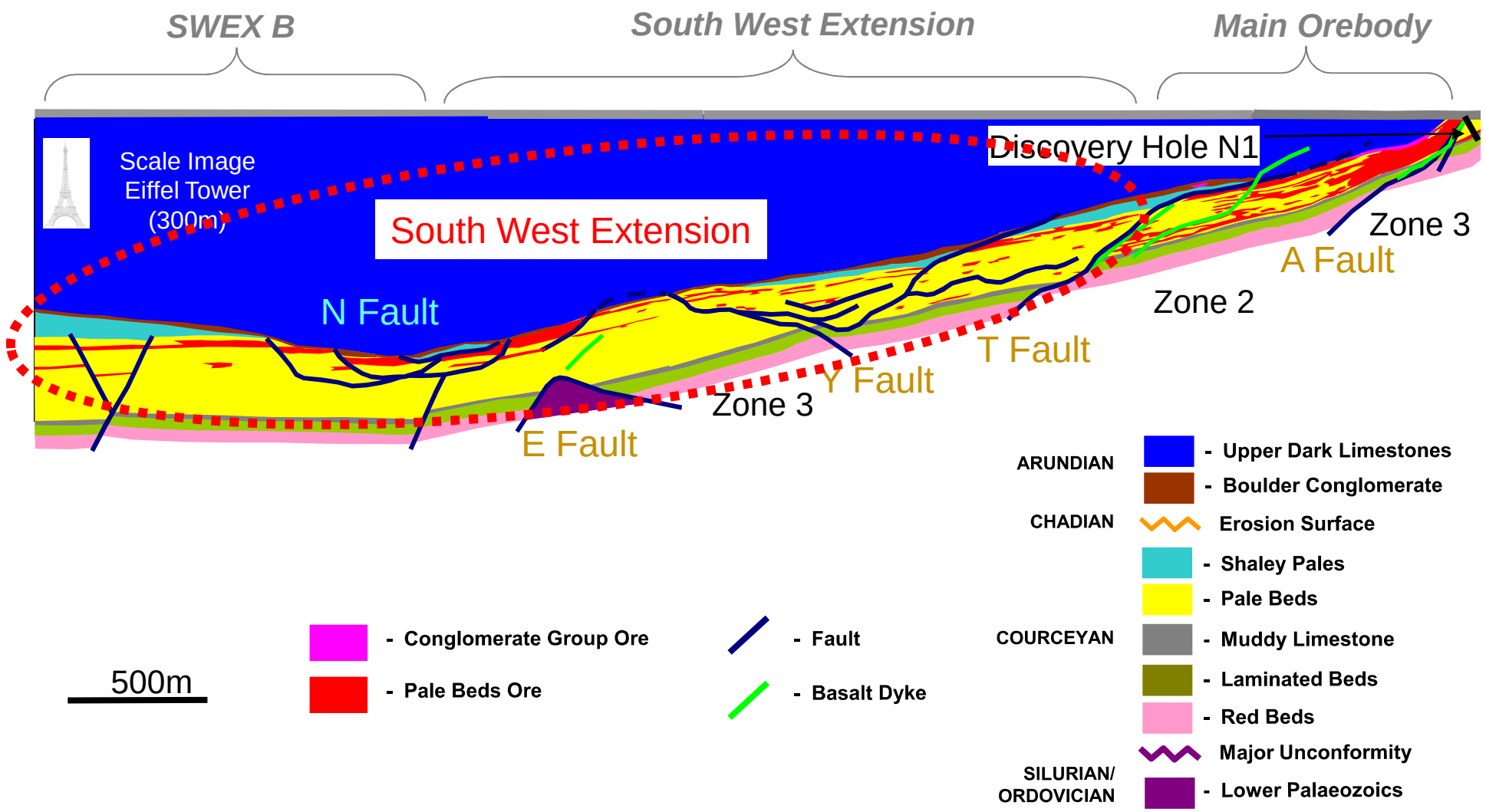



NEVINSTOWN
LISCARTAN
TOTAL NEVINSTOWN
Reserves: 5.8Mt @ 8.3% Zn, 1.6% Pb
Resources: 2.3Mt @ 8.2% Zn, 1.7% Pb
TOTAL LISCARTAN
Reserves: 0.1Mt @ 8.3% Zn, 1.6% Pb
Resources: 0.5Mt @ 6.6% Zn, 1.6% Pb
River Blackwater
1 km
N
Randalstown Castle Faults
B Fault
T Fault
A Fault
C-D Faults
TOTAL MAIN MINE
Reserves: 3.8Mt @ 8.7% Zn, 2.4% Pb
Resources: 6.1Mt @ 5.0% Zn, 2.8% Pb
TOTAL SWEX (Including SWEXB/C)
Reserves: 6.2Mt @ 8.6% Zn, 1.7% Pb
Resources: 8.2Mt @ 9.0% Zn, 1.8% Pb
Eastern Limit of SWEX Capital Project
M Fault
SWEXB
SWEXC
E Fault
SOUTH WEST EXTENSION
N Fault
SWEX 'High Grade Area'
South West Extension
GRAND TOTAL NAVAN OREBODY
Reserves: 15.9Mt @ 8.5% Zn, 1.8% Pb
Resources: 17.1Mt @ 7.4% Zn, 2.1% Pb
NEW BOLIDEN
Boliden Tara Mines Limited
Plan of the Navan Orebody Showing JORC Classified Reserves & Resources at 31/12/2005

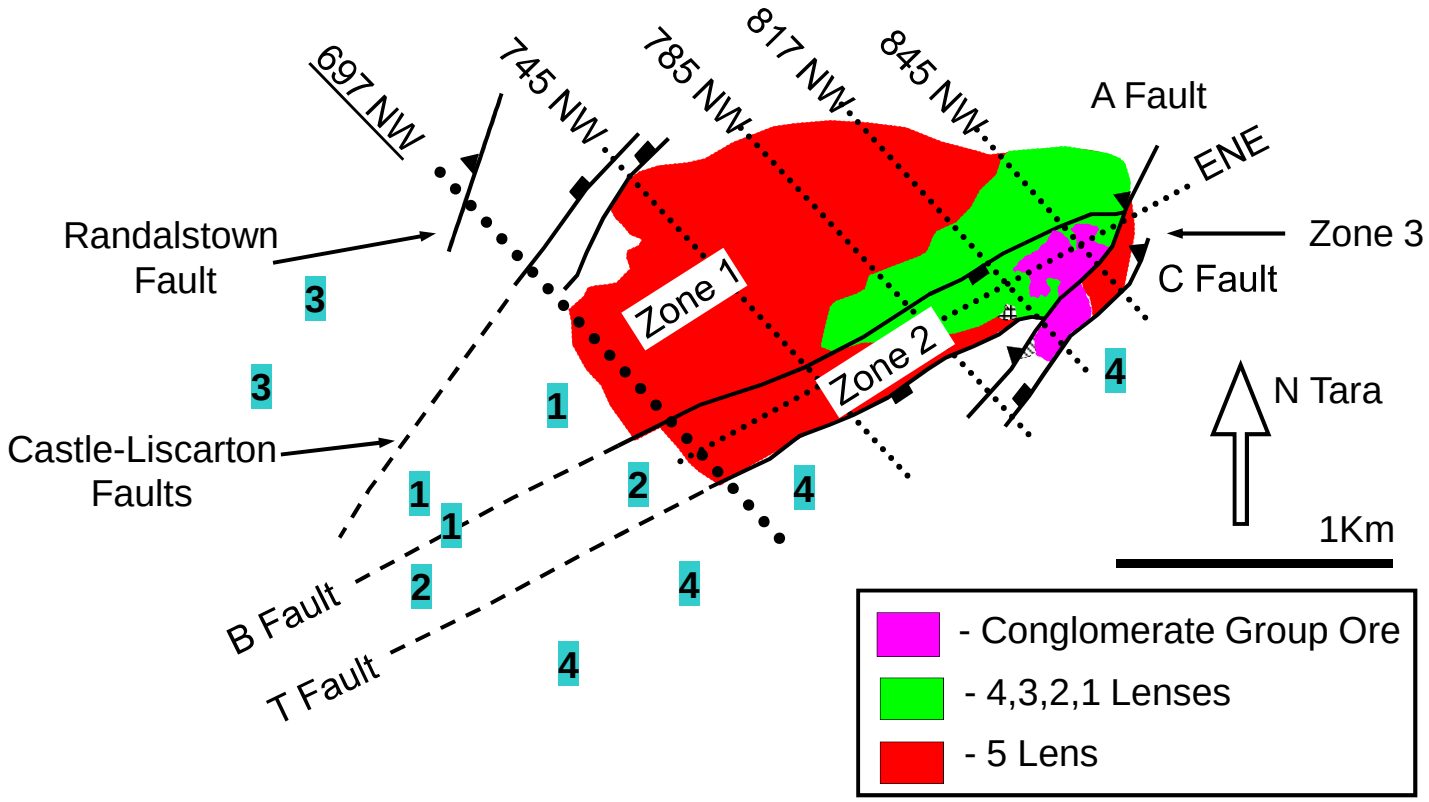
WSW-ENE Dip Section from the Western End of the SWEX to the Eastern End of the Navan Orebody

WSW

ENE

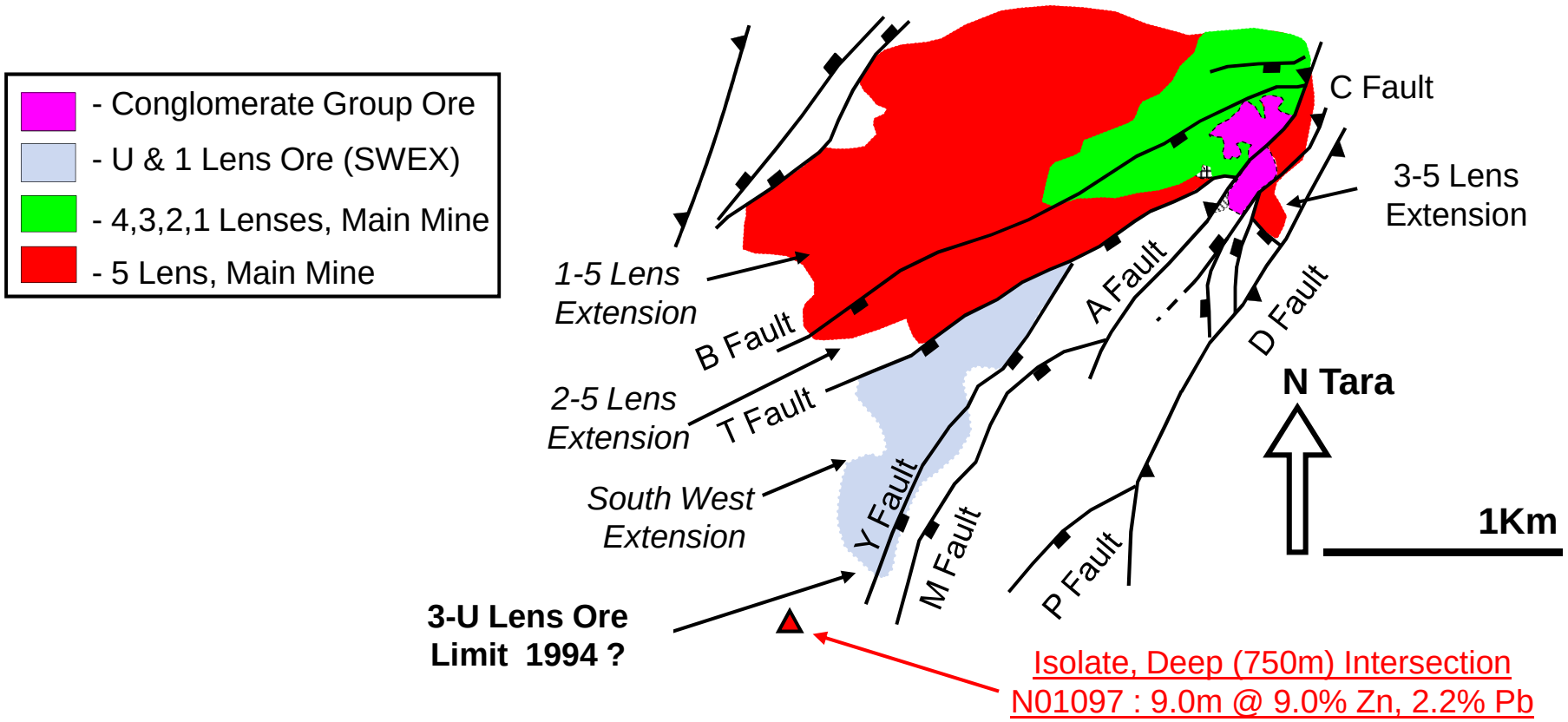


Navan Orebody -1990 Exploration Plan (Drill Targets)



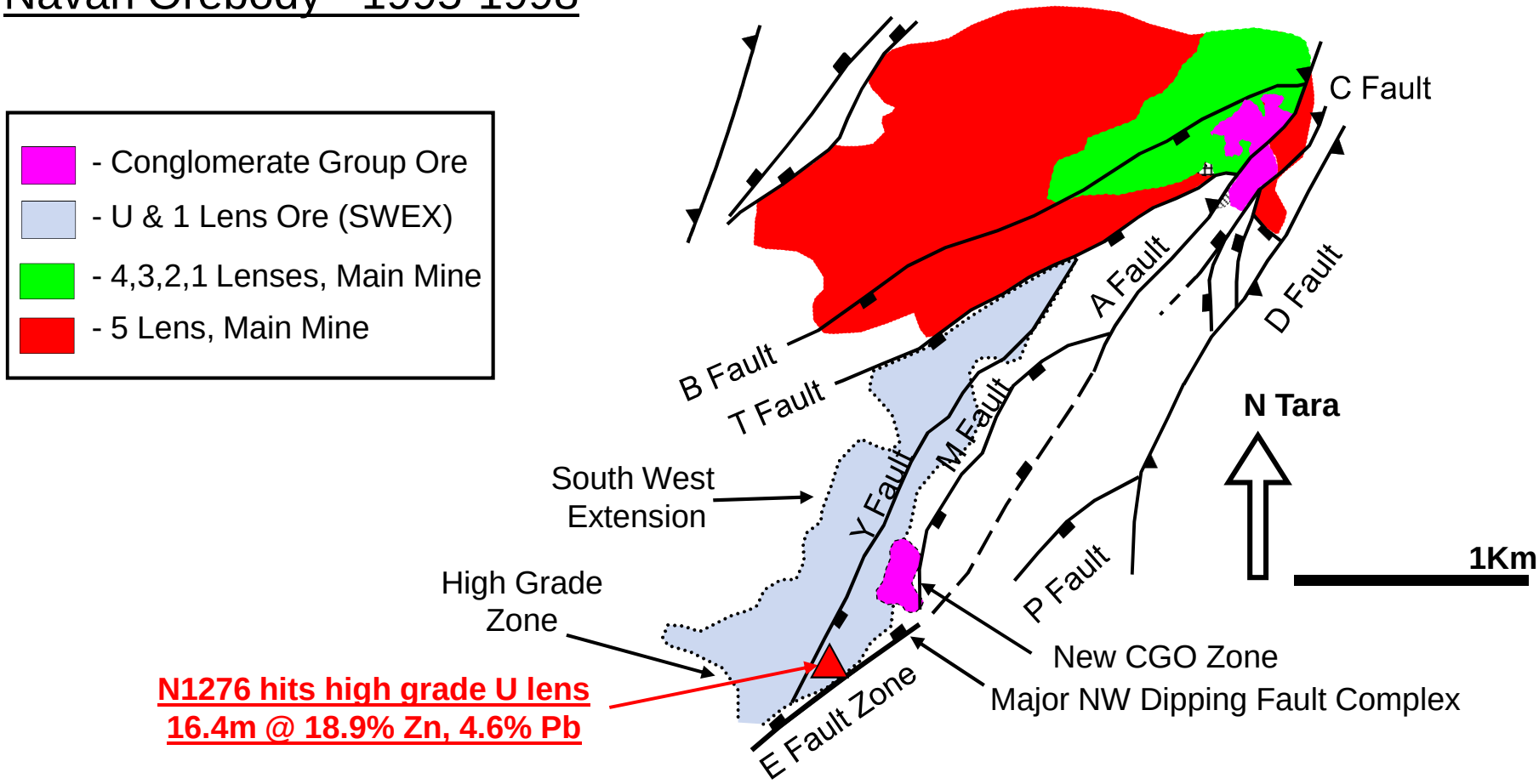
PRIORITY	EXPLORATION TARGET	RESULTS
1	**1-5 Lens Western Extensions**	***Ore thinned and died out.***
2	**2-5 Lens Western Extensions**	***Ore thinned and died out.***
3	**West of Randalstown Fault**	***Poor results, Downgraded to low priority target***
4	**South of T Fault & South of C fault**	***3-5 lens extension. Major D fault structure identified.***
4	**South of T Fault & South of C fault**	***3-5 lens absent but 'new' mineralization in Upper Pale Beds e.g. N1020 : 22.7m grading 6.3% Zn+Pb***

Navan Orebody -1991-1994



EXPLORATION RESULTS	RESOURCES GENERATED
New "3-U" Ore Lens identified in Upper Pale Beds.	3-U Lens: **1992: 0.5Mt @ 7.1% Zn, 1.5% Pb** **1993: 5.2Mt @ 6.8% Zn, 1.4% Pb** **1994: 4.8Mt @ 6.9% Zn, 1.4% Pb** 3-1 Lens: **1.4Mt @ 7.0% Zn, 1.9% Pb** **1.5Mt @ 6.8% Zn, 1.8% Pb**
South West Extension (SWEX) discovered.	
SW-NE Extent: >1Km.	
Major New SE Dipping Y and M normal faults identified	
SW limit of 3-U lens reached but step out hole some 500m SW indicated further potential at depths of ~750m.	

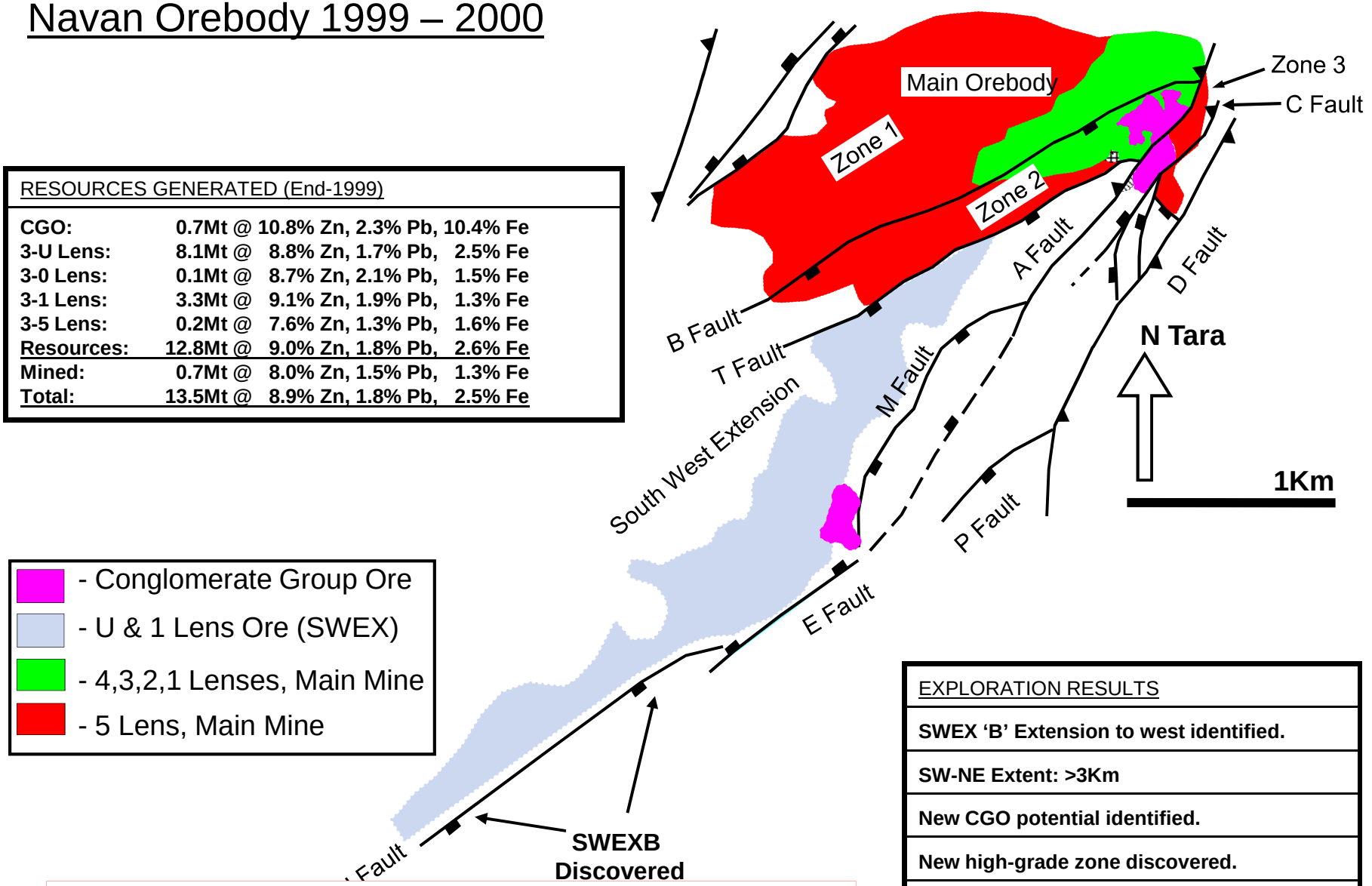
Navan Orebody - 1995-1998



EXPLORATION RESULTS	RESOURCES GENERATED
• **High-grade zone of 3-U & 3-1 lens ore.**	3-U Lens: 3-1 Lens,CGO, etc:
• **SW-NE Extent: >2Km.**	**1995: 5.7Mt @ 6.8% Zn, 1.4% Pb** **1.4Mt @ 7.3% Zn, 1.9% Pb**
• **Major emphasis on directional drilling.**	**1996: 7.2Mt @ 8.9% Zn, 1.8% Pb** **3.9Mt @ 8.3% Zn, 1.7% Pb**
New area of Conglomerate Group Ore.	**1997: 10.3Mt @ 7.9% Zn, 1.6% Pb** **3.9Mt @ 8.1% Zn, 1.7% Pb**
NW dipping fault complex found (A-C Extension ?).	**1998: 10.2Mt @ 8.0% Zn, 1.6% Pb** **4.8Mt @ 8.8% Zn, 1.7% Pb**
	SW limit of SWEX reached...?

Navan Orebody 1999 – 2000

RESOURCES GENERATED (End-1999)			
CGO:	**0.7Mt @**	**10.8% Zn, 2.3% Pb,**	**10.4% Fe**
3-U Lens:	**8.1Mt @**	**8.8% Zn, 1.7% Pb,**	**2.5% Fe**
3-0 Lens:	**0.1Mt @**	**8.7% Zn, 2.1% Pb,**	**1.5% Fe**
3-1 Lens:	**3.3Mt @**	**9.1% Zn, 1.9% Pb,**	**1.3% Fe**
3-5 Lens:	**0.2Mt @**	**7.6% Zn, 1.3% Pb,**	**1.6% Fe**
Resources:	**12.8Mt @**	**9.0% Zn, 1.8% Pb,**	**2.6% Fe**
Mined:	**0.7Mt @**	**8.0% Zn, 1.5% Pb,**	**1.3% Fe**
Total:	**13.5Mt @**	**8.9% Zn, 1.8% Pb,**	**2.5% Fe**



EXPLORATION RESULTS
SWEX 'B' Extension to west identified.
SW-NE Extent: >3Km
New CGO potential identified.
New high-grade zone discovered.
Remains 'open' to North, South and West

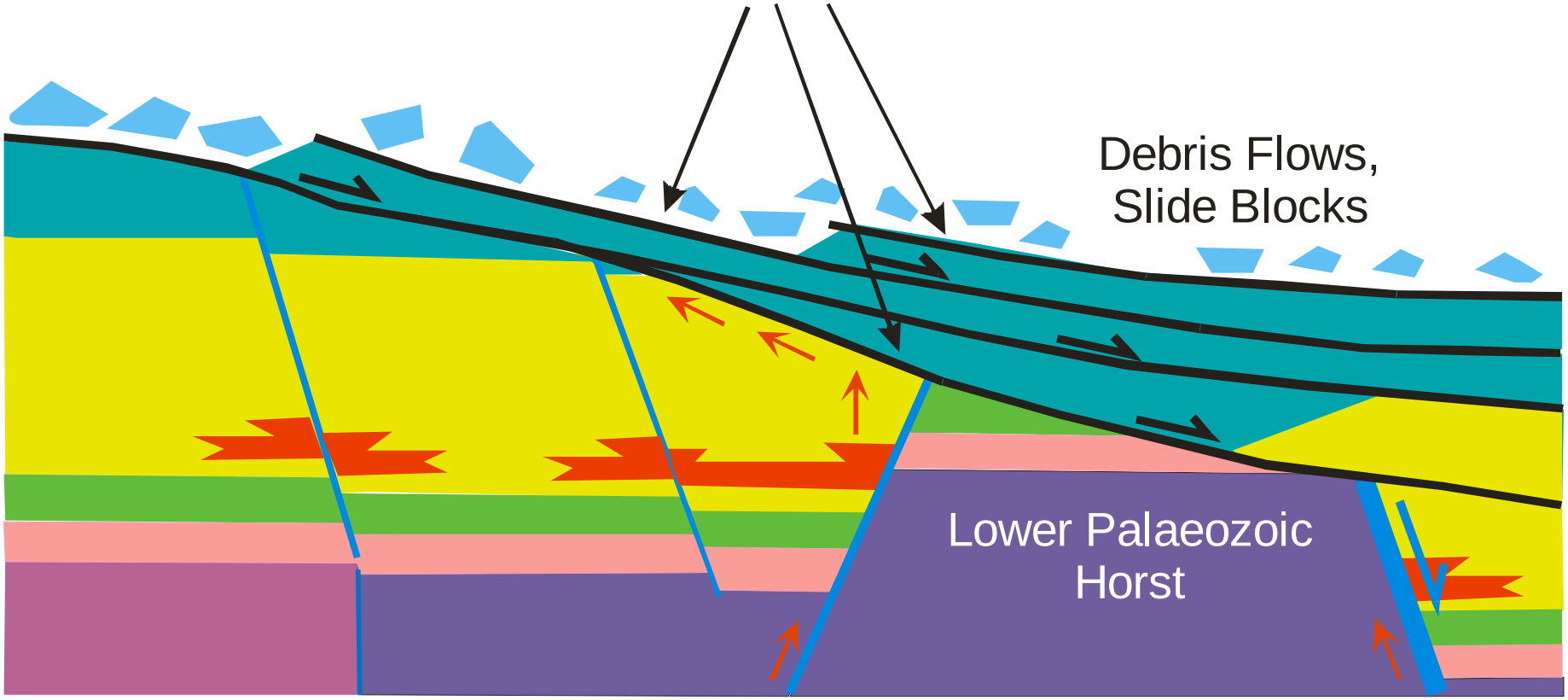
Current and Future Drilling Driven by Geological Knowledge

Stage III - Major Sliding (Chadian)

Differential subsidence to south incrteases rapidly towards developing Dublin Basin
‘Large SE Dipping Faults are truncated by footwall degradation . .

Sea-Level

Extensive development of transient and compositegravity
slides directed southwards into rapidly deepening Dublin Basin . .

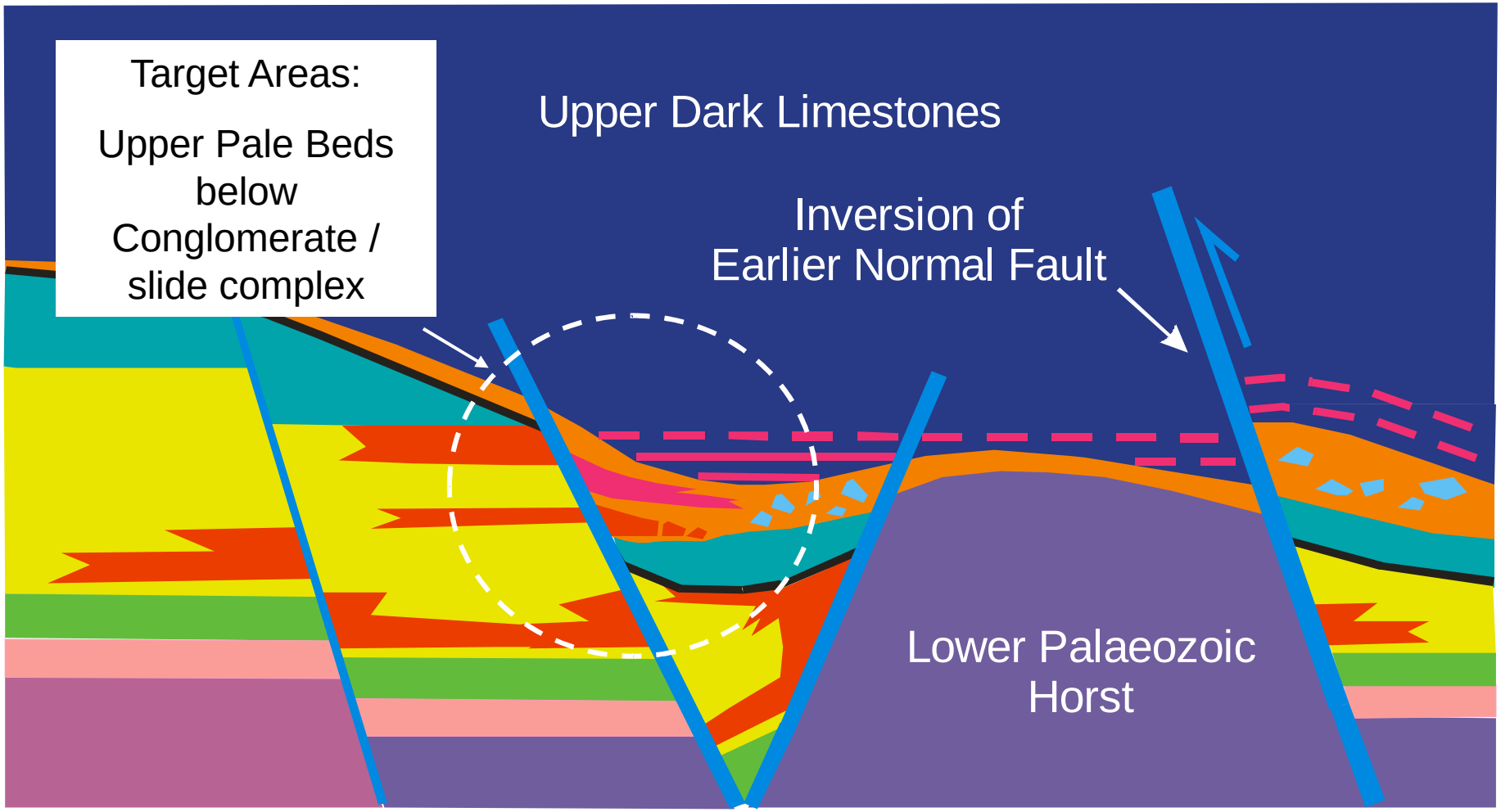


Major extension, Dublin Basin developing to South

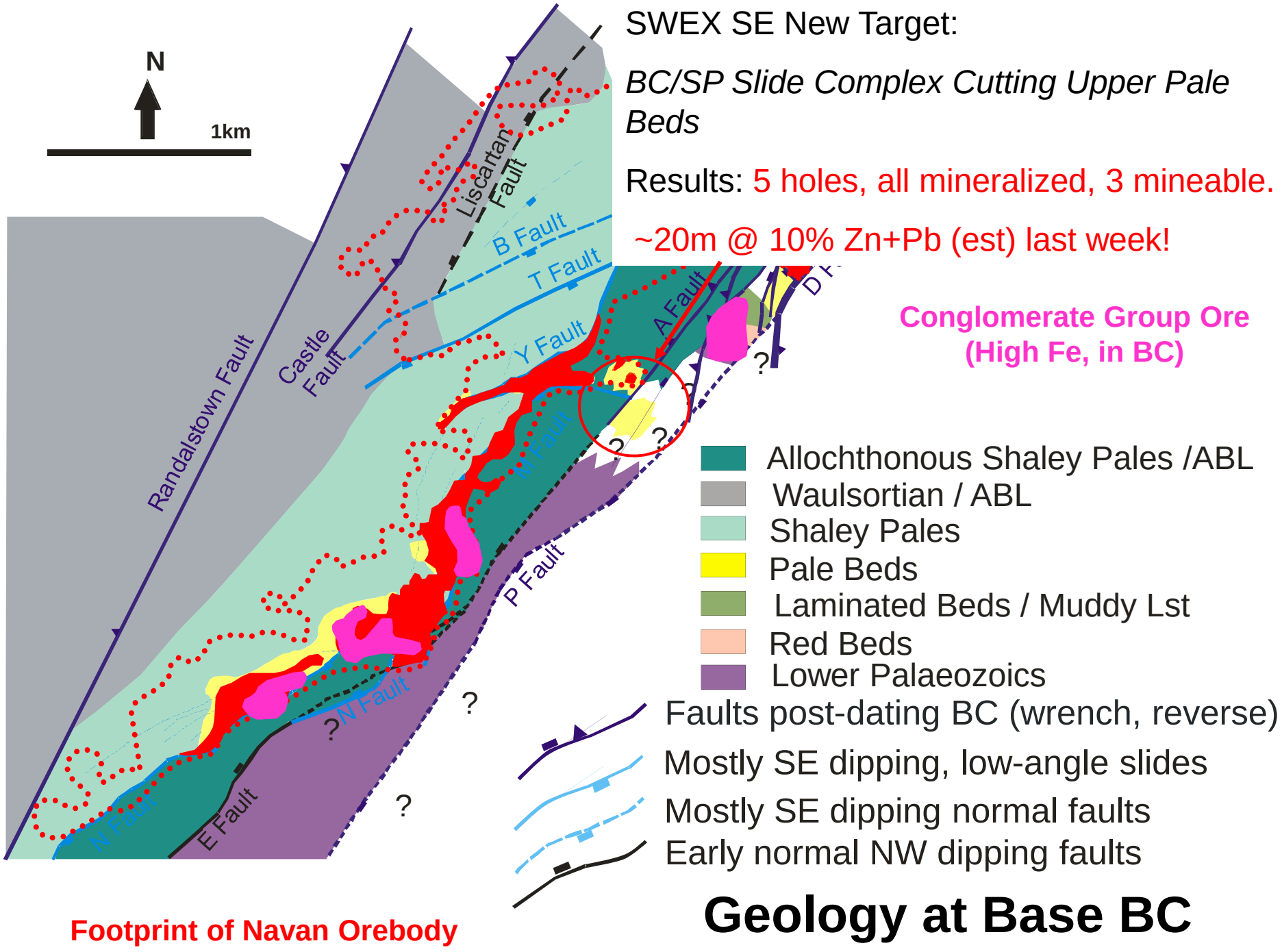
Hydrothermal fluids constrained by slides
fracture fill + breccia hosted mineralization . .

Stage V - Basin Inversion (late Carboniferous)

Major wrench (predominantly dextral) and reverse reactivation on major faults
Development of NNW trending folds in Upper Dark Limestones
Development of regional NNW trending joint sets



Mineralization complete during Arundian
No mineralization linked to end Carboniferous event



SWEX SE New Target:

BC/SP Slide Complex Cutting Upper Pale Beds

Results: 5 holes, all mineralized, 3 mineable.

~20m @ 10% Zn+Pb (est) last week!

Conglomerate Group Ore (High Fe, in BC)

Footprint of Navan Orebody

Geology at Base BC

Navan Extensions - Comment

Management support and funding were critical.

Persistence pays off.

Recognition that historically sub-grade 3-U horizon was a new target.

Several episodes where we thought the ore had run out . . ..

Follow-up underground drilling further boosted reserves.

Scientific R&D by mix of company staff, university research and consultants leads to better target generation.

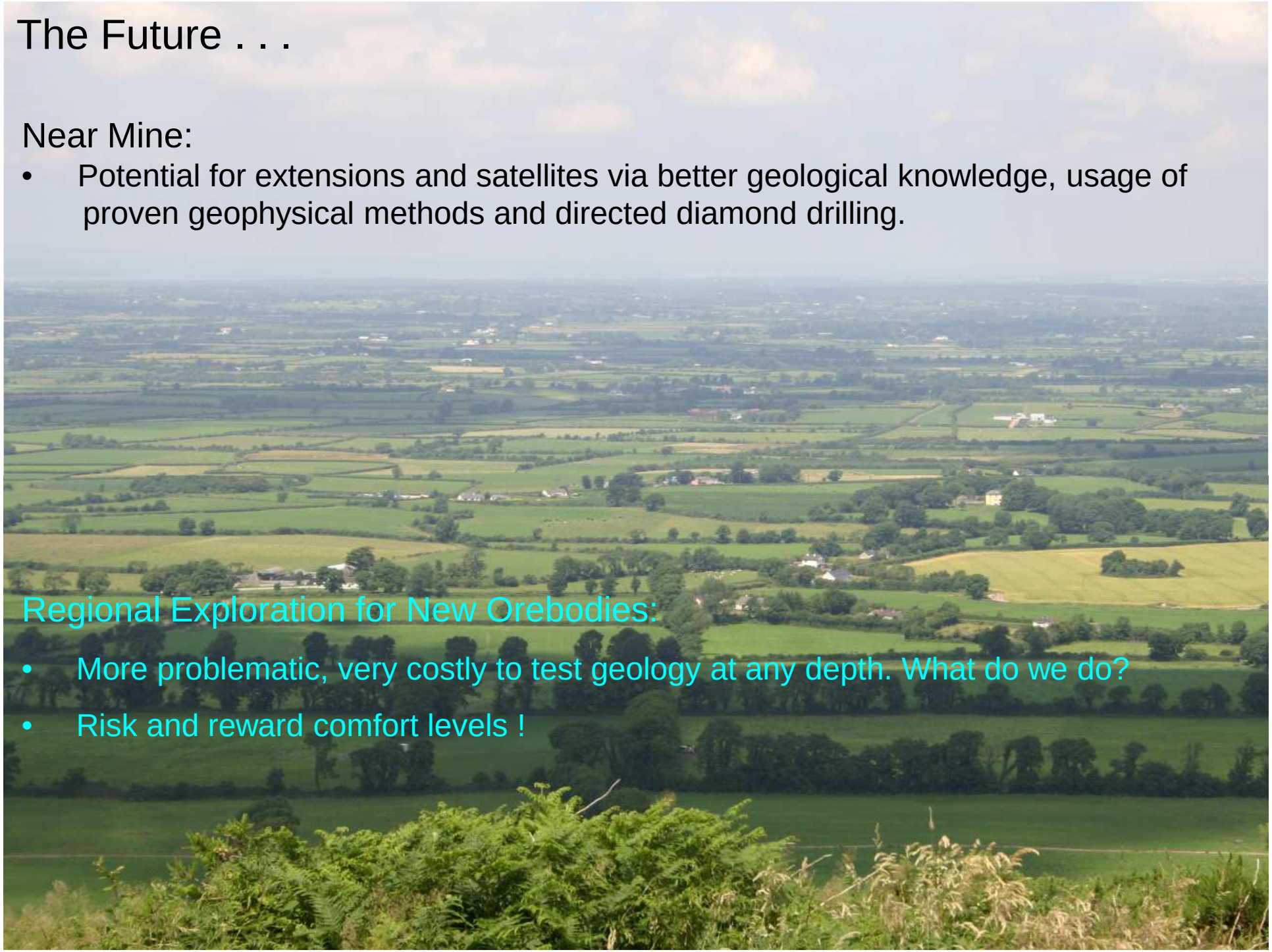
Navi-drilling technology helped deep drilling (time/cost/location).

The deep lateral contination of ore some 5km away from the initial surface discovery boosts confidence in deep regional exploration.

The Future . . .

Near Mine:

- Potential for extensions and satellites via better geological knowledge, usage of proven geophysical methods and directed diamond drilling.



Regional Exploration for New Orebodies:

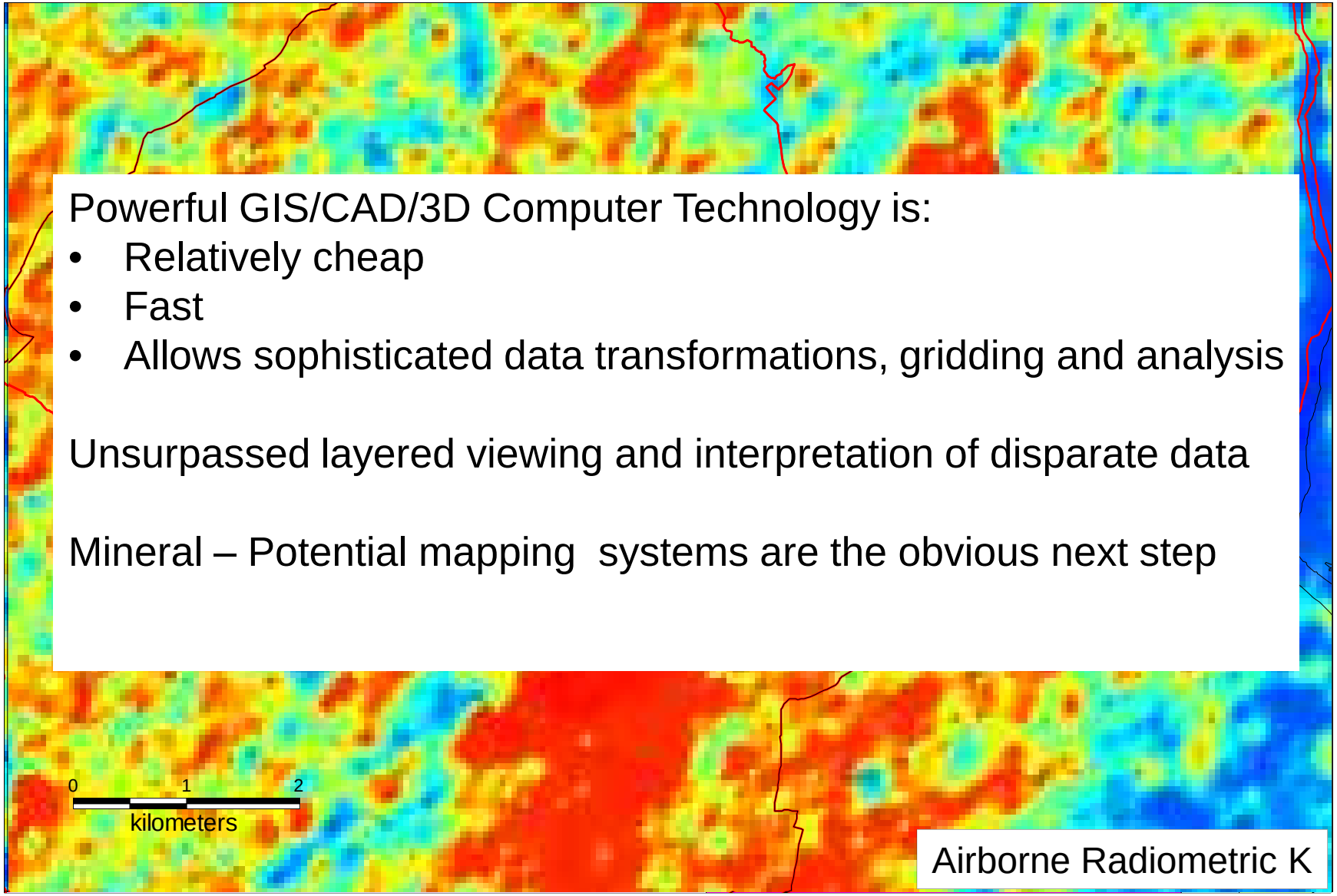
- More problematic, very costly to test geology at any depth. What do we do?
- Risk and reward comfort levels !

Future Exploration

OK Risks Accepted, More seriously, what are the possibilities?

- Better analyses of the wealth of existing data, (+Airborne Geophysics).
- Good recent geological research, new geological models, SCIENCE, R&D.
- Litho-geochemical methods and mobile ion/ enzyme leach approaches.
- Deeper penetrating geophysical methods (IP, EM, Gravity, Seismic).
- Database / GIS tools to analyse multi-parameter (+ multi-legacy!) data.
- Mineral-potential prospectivity mapping – analysis of the large data bank ?
- Better drilling technology.

GIS Layering



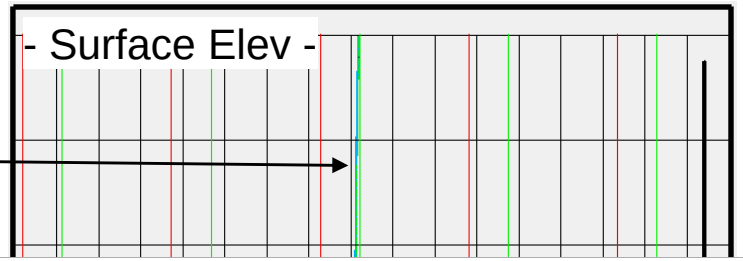
(Location: Not necessarily in the Irish Midlands . .)

Drilling Technology

Increase effective depth penetration:

- Navi-Drilling
- Down-Hole Hammer
- Other ?

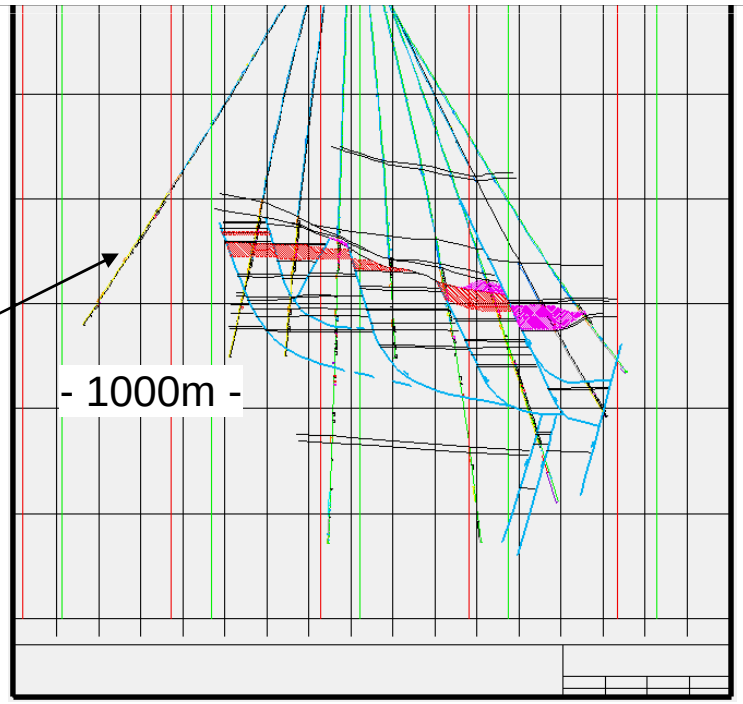
Navi-Drilling



Mother Hole

Navi-Drilling Advantages:

- Cheaper way of obtaining multiple intersections
- Minimises surface disturbance
- Rig can be placed in environmentally optimum position
- Holes can be steered below inaccessible areas (houses, bogs etc)



Navi-Drill deflections
From mother hole

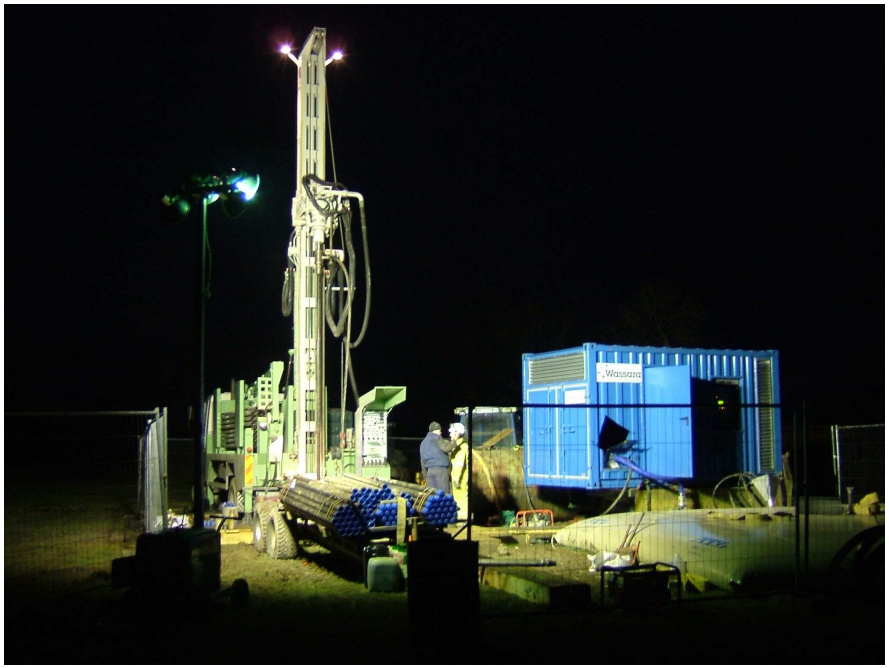
Drilling Technology

e.g. Wassara Hammer Testwork, Navan

Concept: Cheap, rapid open hole drilling with water-operated down hole hammer to +500m depths followed by conventional diamond drilling (coring). Increases practical depth penetration and speed of diamond-drill exploration/delineation.

Progress:

- 4 holes drilled, penetration rates 1st hole 557m in ~67 hours, 2nd hole 357m in <32.5 hours
- Initial hole locally too ‘bent’ to allow diamond drilling and concerns on maintaining ‘verticality’
- Second hole better, awaiting diamond drilling, but some concern regarding local deviations
- Third/fourth tests drilled with extra stabilizers, concluded that better stabilizers still required.



Final Thoughts and something for everybody . .

Ireland's current successful Zn-Pb mining industry is (imminently) FINITE.

Exploration Industry:

Geologically still very prospective, technological advances feasible, increasing depth penetration required will be expensive.

Contractors:

Cheaper/new drilling technology - a key issue for increased depth penetration.

Mining Companies:

Current mines have excellent environmental track records. This needs to be maintained after mine closures – let's leave behind something good!

Irish State:

Further support and clarity would assist the industry (data release, tax, mining facility terms, faster planning/licensing, R&D, innovative waste disposal etc).

Recent massive changes in the worldwide mining/exploration industry, coupled with a metals super-cycle? – an opportunity too good to be missed for Ireland 'Limited' ?