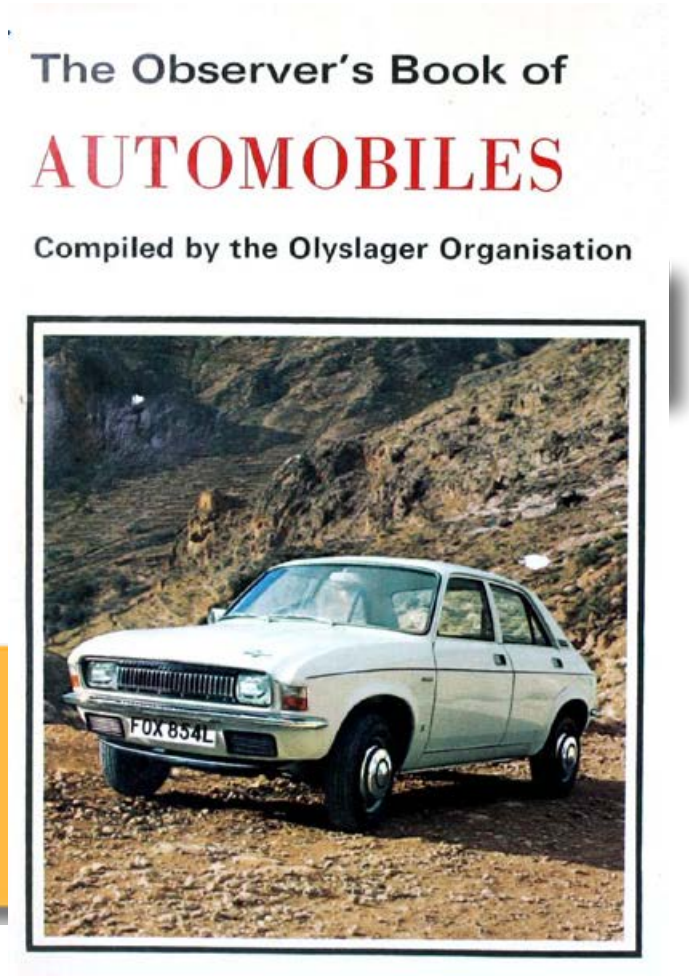
The Observer's Guide to Potash!



Mark Arundell
IMEx Consulting

Before we begin….

- ***Acknowledgements***
  - Iain Scarr – Galaxy Resources, Salta, Arg
  - Ron Brown – Regina, Sk
  - Bob Hite – USGS, Co
  - Hugh Harvey – Intrepid, Co

- ***Disclaimer***
  - Not definitive – "Potash 101"
  - Potash is not Phosphate
  -

The IMEx Group - Experience

Exploration Projects and Regional Studies

▲ IMEx Office

Without a market,
a deposit is merely a geological curiosity - Harben

Potash

- What's Potash?
- Why Potash?
- Geology - setting & examples
- Mining - conventional & solution
- Exploration Criteria & Tools

Potash

IMEx Consulting
global expertise to build your resource base

Polish potash war elicits investor interest

SPINIFEX

Nick Sas

Potash potential: Potash West managing director Patrick McManus says fertiliser groups are expressing more interest.

The West Australian
Monday, September 9, 2013

It is an odd time in the small resources sector, when commodities such as potash and mineral sands attract serious investor attention in WA.

With many gold and nickel investors hurt over the past six months, the lure of diversification is becoming more attractive.

The announcement by BHP Billiton last month that it was pumping in $2.6 billion to finish the Jansen Potash project in Canada — particularly in light of BHP shareholders' push for spending restraint — is one factor pushing potash into the spotlight.

Another factor is the entertaining, albeit slightly worrying, so-called potash wars between Russia and Belarus, which have also helped put the fertiliser feed back on the map.

For the record, Vladislav Baumgertner, chief executive of the mining group Uralkali, was detained in Minsk, Belarus, late last month.

Uralkali sparked a row when it quit a trading alliance with State potash producer Belaruskali in a move that analysts say could push potash prices down by as much as 25 per cent before the end of the year.

The halls of the Perth Convention Centre are a long way from the jails of Minsk but according to Potash West managing director Patrick McManus, the reverberations have been felt by his company.

Potash West is attempting to develop the Dandaragan Trough project 150km north of Perth, and Mr McManus said a number of curious investors came to find out more about the company during last week's Association of Mining & Exploration Companies conference.

For Potash West, the immediate threat of decreased prices from the potash war does not have a huge impact but the lingering long-term food security threat does.

Analysts have tipped this issue will become more perverse in the latter half of this decade, if not sooner.

Mr McManus admitted Potash West liquidity and, indeed, its share price, were low but he said inquiries from fertiliser groups had increased.

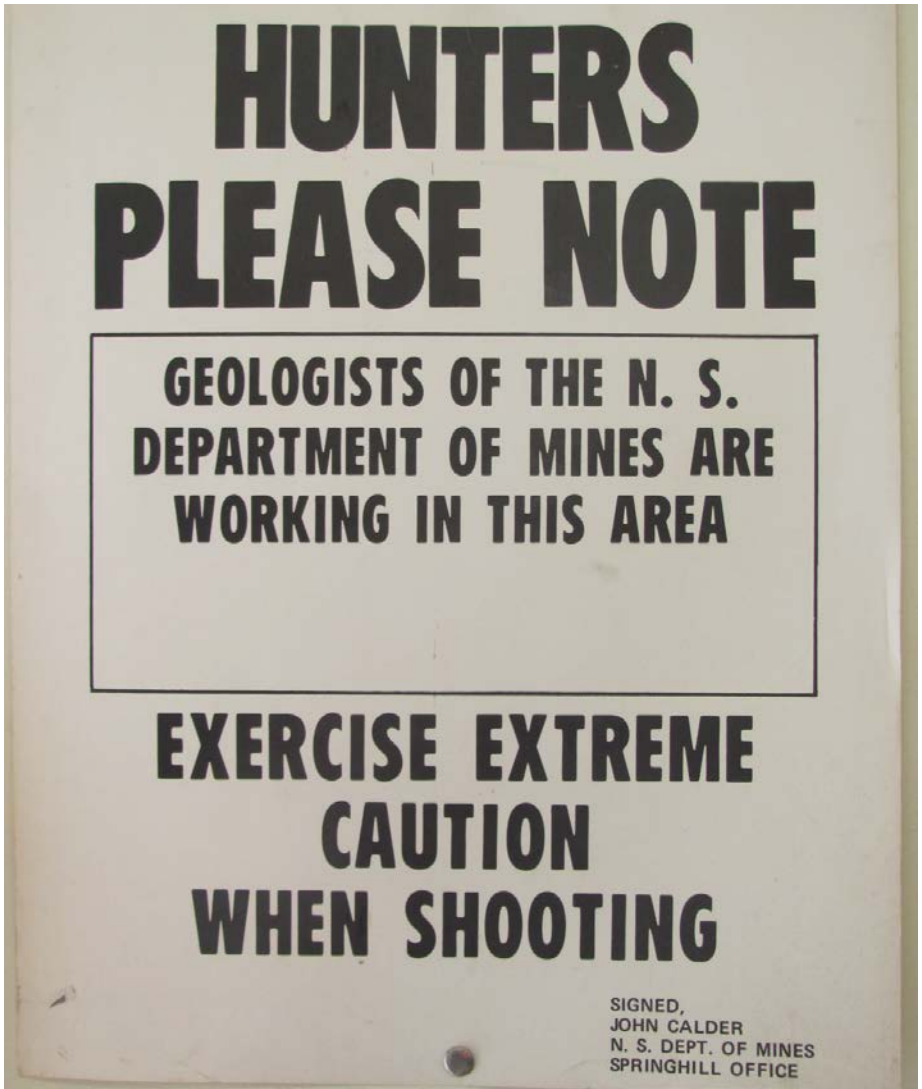
In January, the company put a $650 million price tag on a 2.4 million-tonne-a-year operation that aims to mine potassium-rich glauconite — an essential product in the creation of fertiliser — with an eventual plan to ship 50 per cent of the product to South-East Asia and China.

He said the company's next step was to start construction of a working trial plant.

■ On the mineral sands front, Welshpool-based Mineral Commodities Limited highlighted the relative confidence in the sector by announcing a fully underwritten $6.5 million entitlement issue late last week. The one-for-four issue is priced at 8¢ — just below the 8.1¢ closing price on Friday. The company said it would use the money to fund the commissioning of its Tormin mineral sands project on South Africa's west coast, 400km north of Cape Town.

nick.sas@wanews.com.au

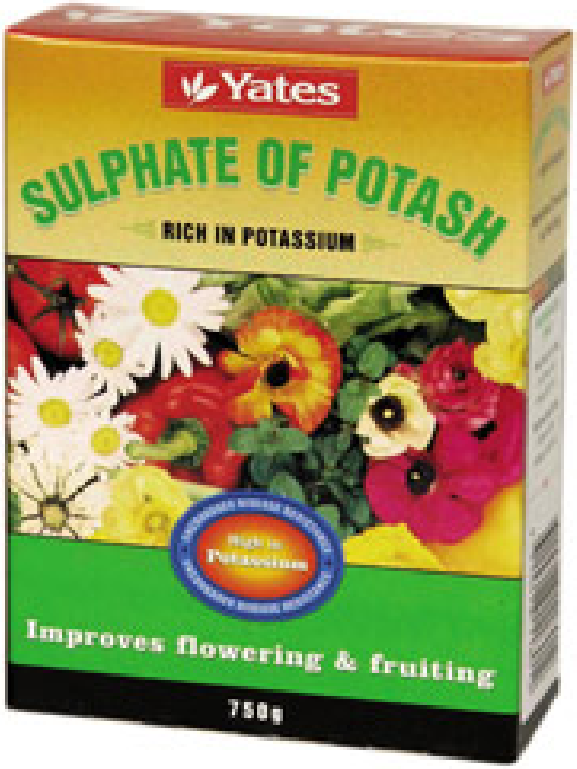
Potash



New Glasgow
Nova Scotia

What's Potash?

- The mineral (K) is one of the three main macro nutrients required by plants, along with nitrogen (N) & phosphate (P)
- Potash helps
  - improve a plant's disease resistance
  - crop quality
  - increases yields
- Only potassium fertilizer source
  - No practical substitutes



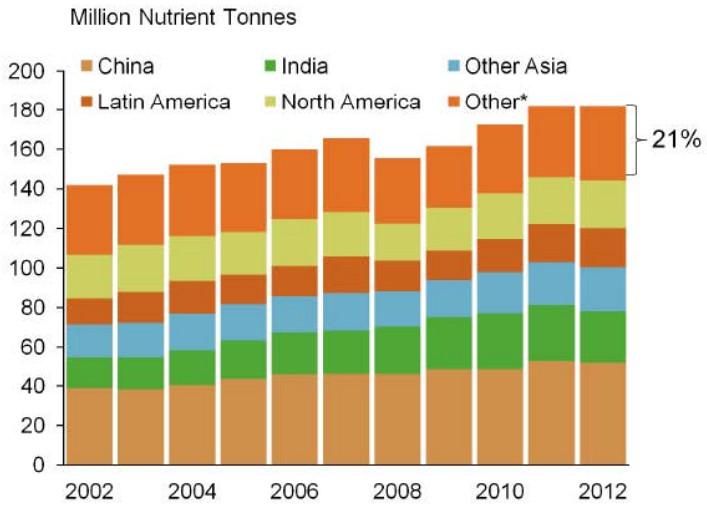
Why Potash?

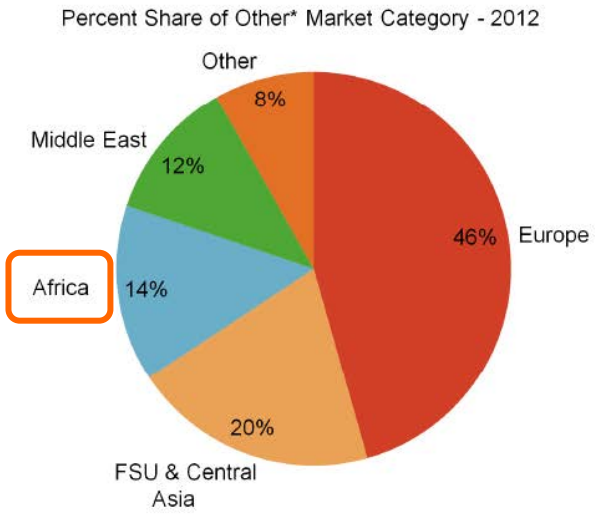
IMEx Consulting
global expertise to build your resource base

It's a Growth Story!!

World Fertilizer Consumption

More than 20 Percent of Consumption Outside of Asia, North and Latin America





Based on a combination of calendar and fertilizer year data.
2012 refers to 2012 CY and 2012/13 FY.

Source: Fertecon, IFA, PotashCorp

Why Potash?

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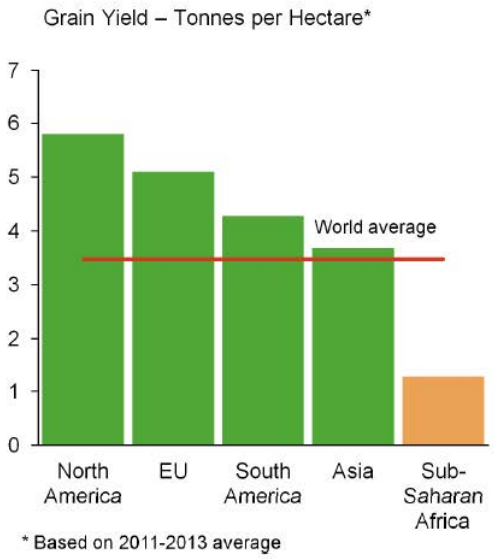
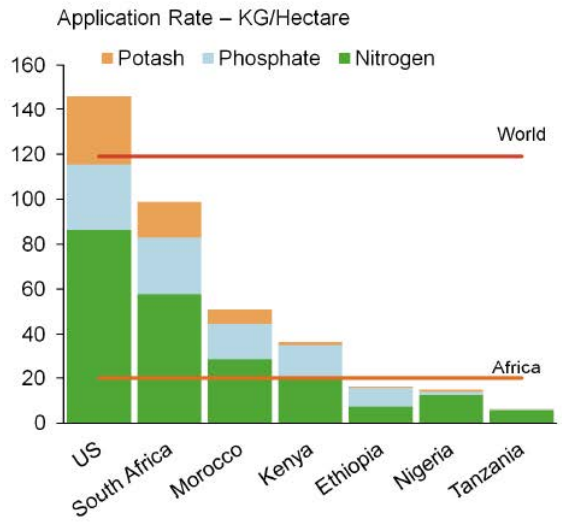
It's not just Asia!

Grain Yields and Fertilizer Use

Yields in Sub-Saharan Africa Lag As Does Fertilizer Use

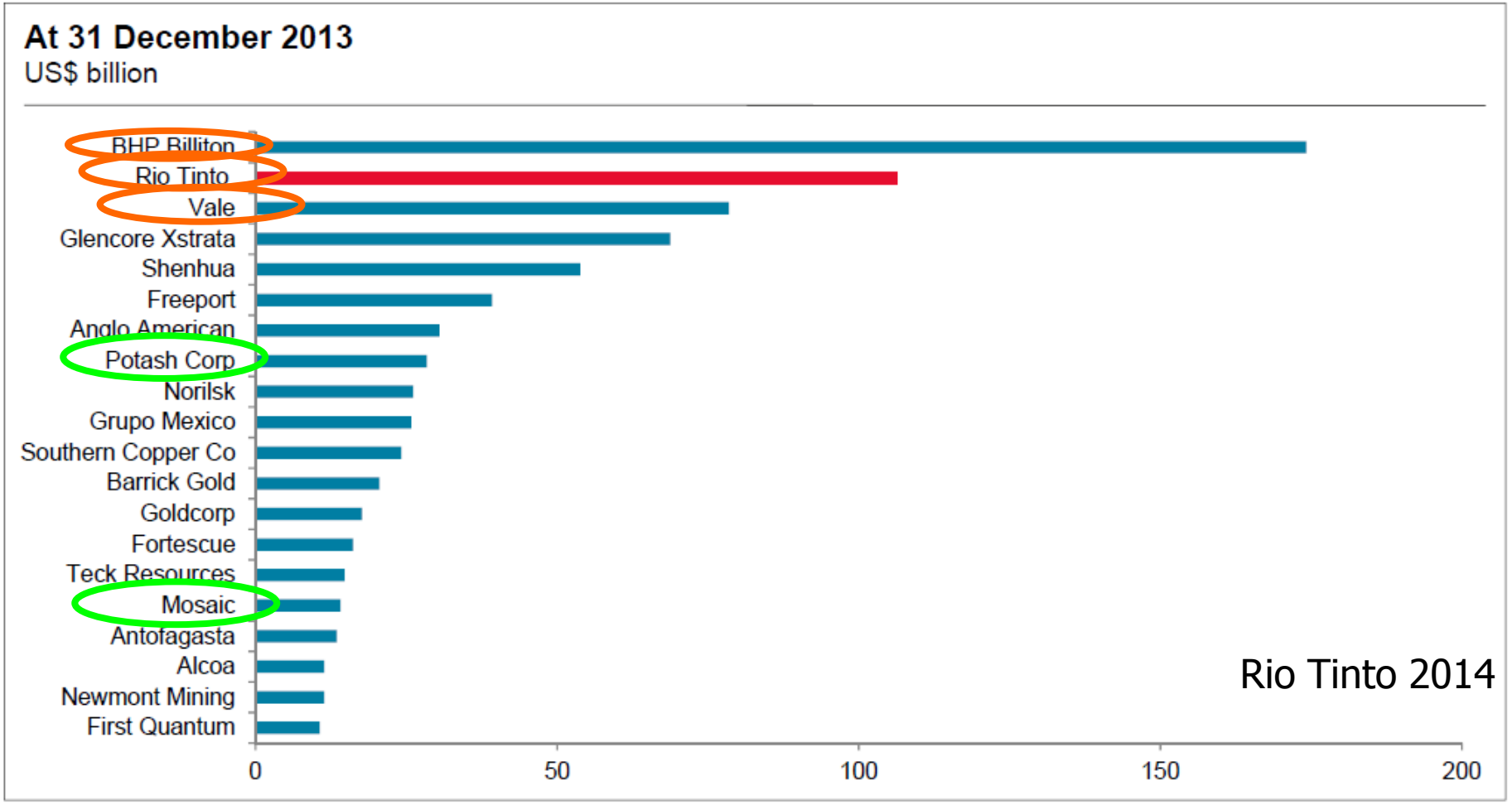


* Based on 2011-2013 average

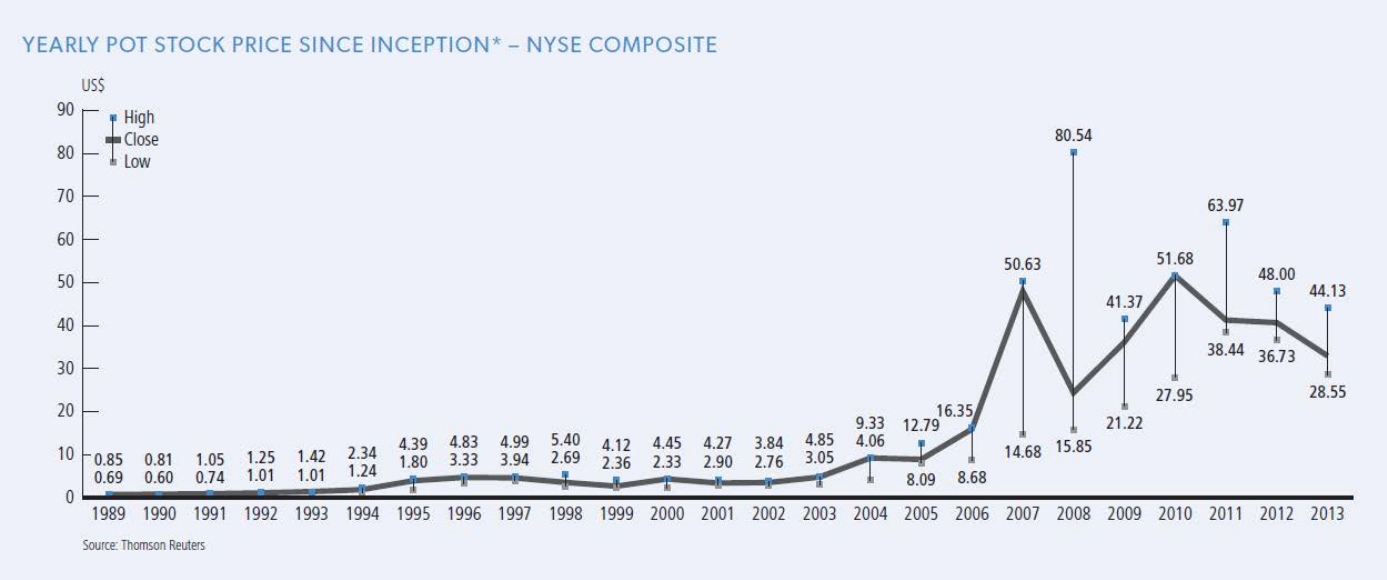


Source: USDA, IFA, FAO, PotashCorp

Why Potash?

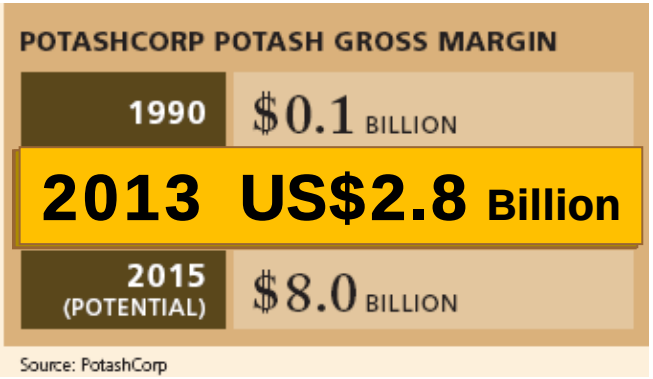

At 31 December 2013
US$ billion
BHP Billiton
Rio Tinto
Vale
Glencore Xstrata
Shenhua
Freeport
Anglo American
Potash Corp
Norilsk
Grupo Mexico
Southern Copper Co
Barrick Gold
Goldcorp
Fortescue
Teck Resources
Mosaic
Antofagasta
Alcoa
Newmont Mining
First Quantum
0
50
100
150
200
Rio Tinto 2014

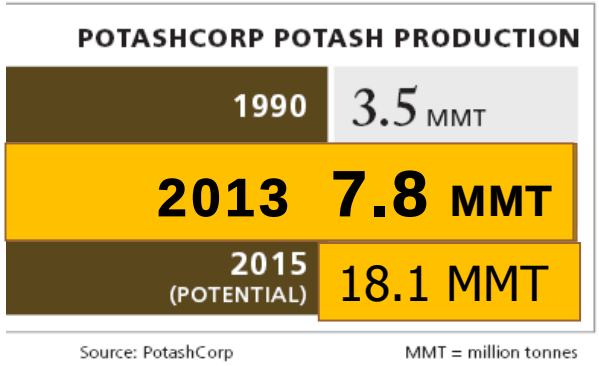
Why Potash? Potash Corp



May 14
US$36.32

2010 :
BHP
US$43.33

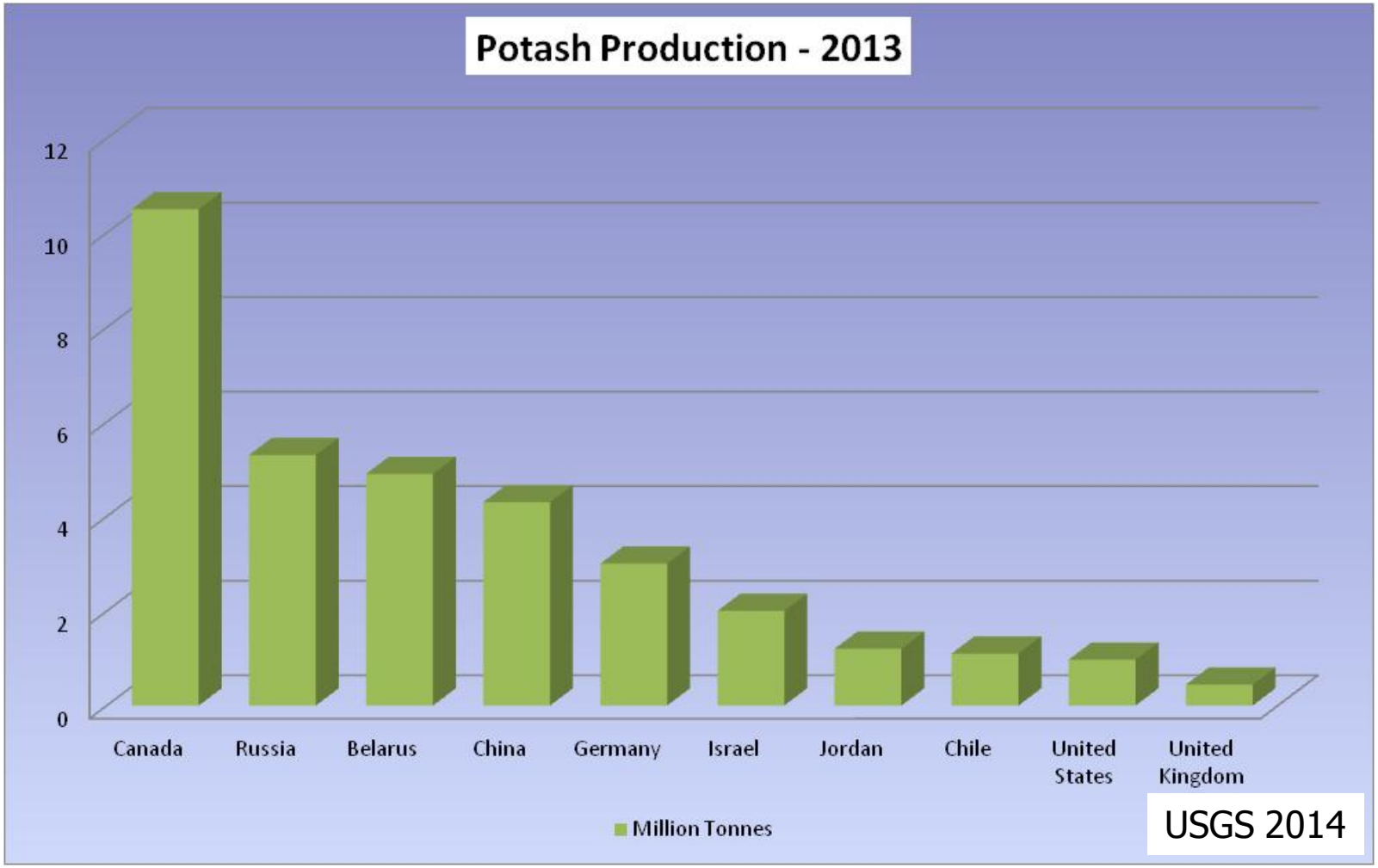




Commodity Overview

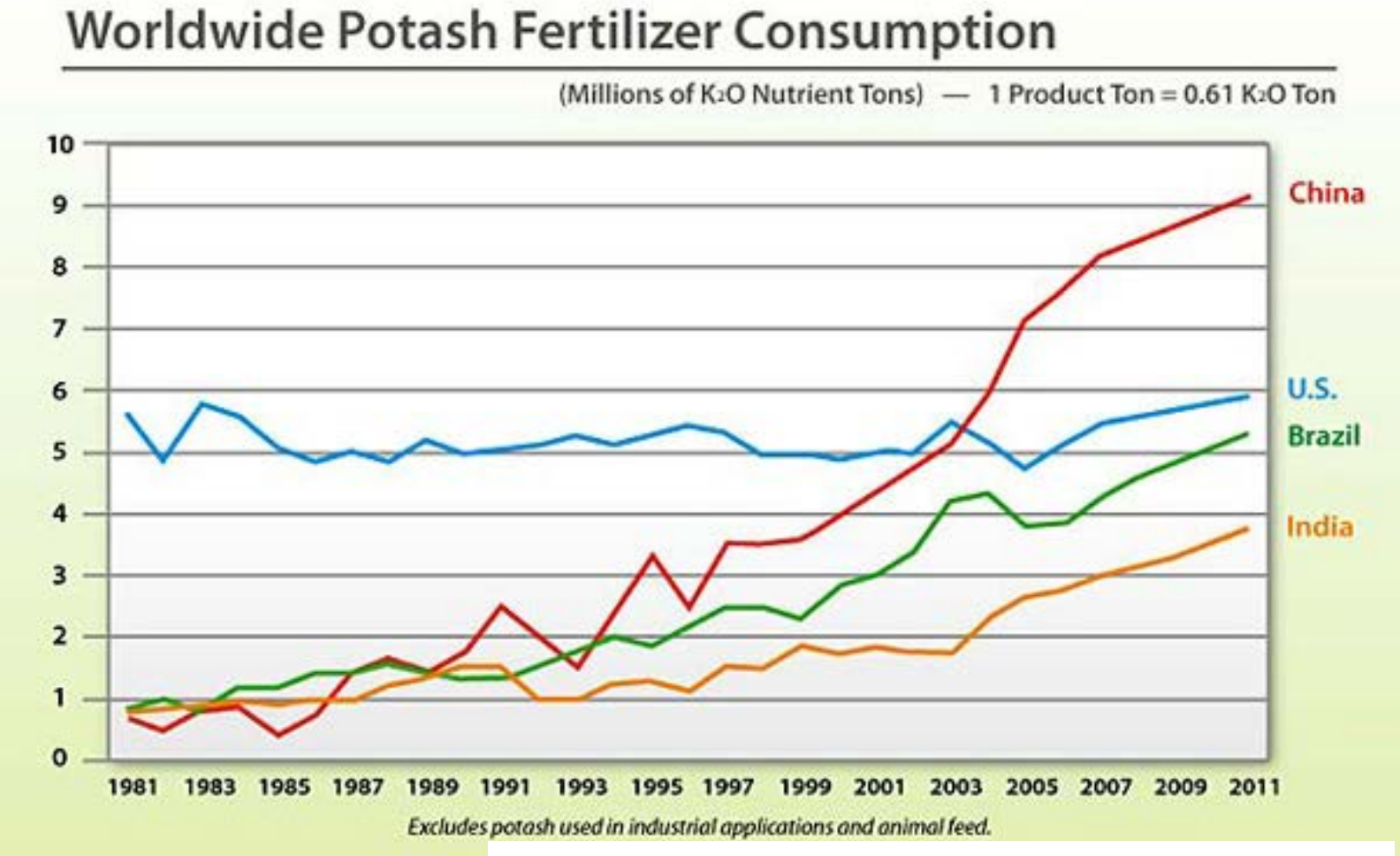
- Only 12 countries produce potash.
  - Canada, Russia & Belarus - +60%
- Seven companies control >80% of global supply:
  - Potash Corp of Saskatchewan, Mosaic Co, Agrium Inc, K+S, Uralkali, Belaruskali & Israel Chemicals
- Two marketing conglomerates **did** control >70% exports.
  - **Canpotex** - Potash Corp, Mosaic and Agrium
  - ~~**Belarussian Potash Co**~~ - Uralkali and Belaruskali.

Commodity Overview



USGS 2014

Commodity Overview



North American Potash Developments website

Commodity Overview

Potassium Chloride Monthly Price - US Dollars per Metric Ton

Range 6m 1y 5y 10y 15y 20y 25y 30y

Apr 2009 - Apr 2014: -458.000 (-61.48 %)

Index Mundi website

Potash One – Legacy PFS

- Legacy Project (Saskatchewan, Canada)
  - NPV $_{10}$ US$4.47B
  - IRR 30.1%
  - Cap. Cost US$1.88B
  - **Payback ~3.3 years**
  - Mine Life 40 years
  - Resource 29Mt (Measured) 220Mt (Indicated)
- Q : Who was the Chairman ?
  - Robert Friedland

Potash One

- November 22, 2010
  - "Potash One Agrees to Friendly Takeover by K+S for CAD 4.50 Per Share in Cash"
  - 31.3% premium over the 10-day weighted average trading price
  - CAD $434 million (€311 million).

K&S Potash Canada

$4.1B, 1,500m; 2016

CIM 2014

Saskatchewan

POTASH

Potash producers in Saskatchewan plan to invest $13.9 billion to upgrade and expand production capacity by more than 90% by 2023. Ten facilities in the province produce nearly one-third of the world's potash.

POTASH PRODUCTION

MINES ON THE HORIZON

2016 K+S Canada's Legacy mine: 2.8 million tonnes per year

2018 BHP Billiton's Jansen mine: 8 to 10 million tonnes per year

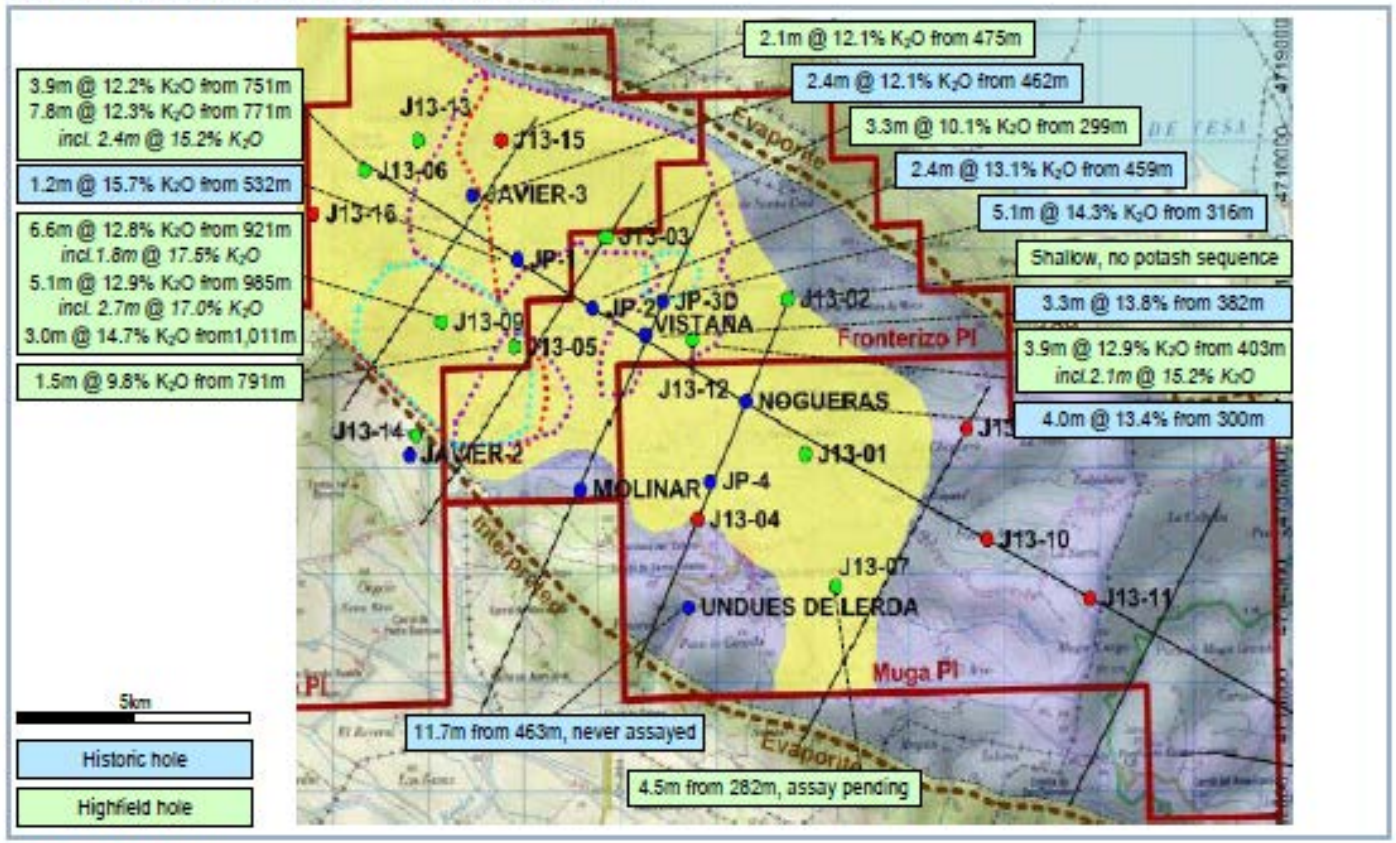
CIM 2014

Highfield Resources

IMEx Consulting
global expertise to build your resource base

Highfield Resources

New drilling at Javier and high-grade intervals, 2km grid

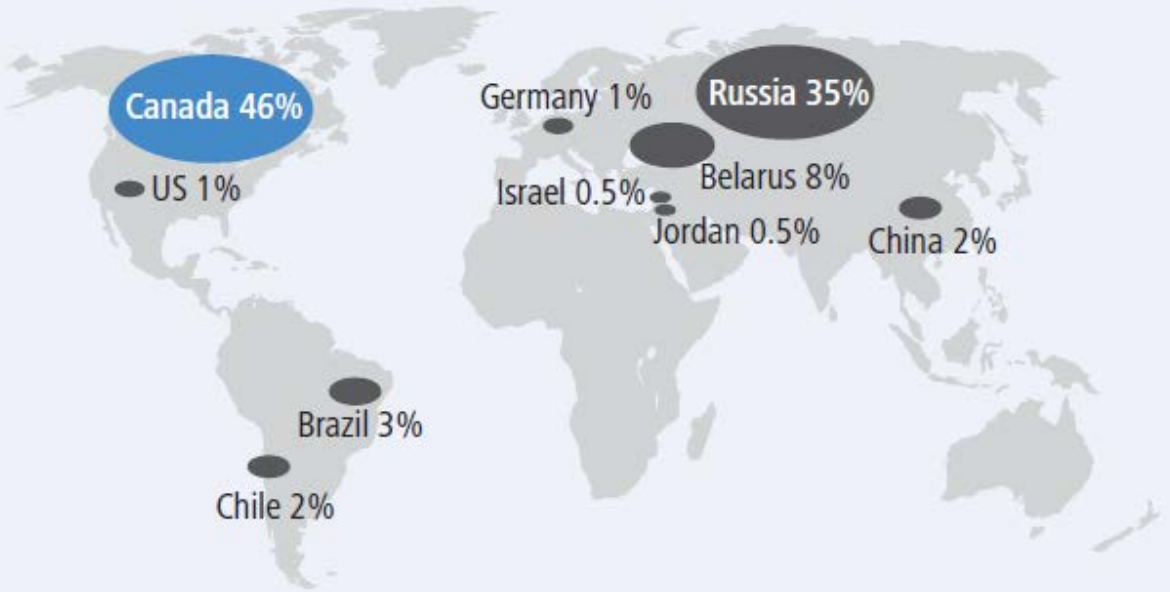


Source: Company data

Where Potash - Reserves

WORLD POTASH RESERVES*

Economically mineable deposits are geographically concentrated

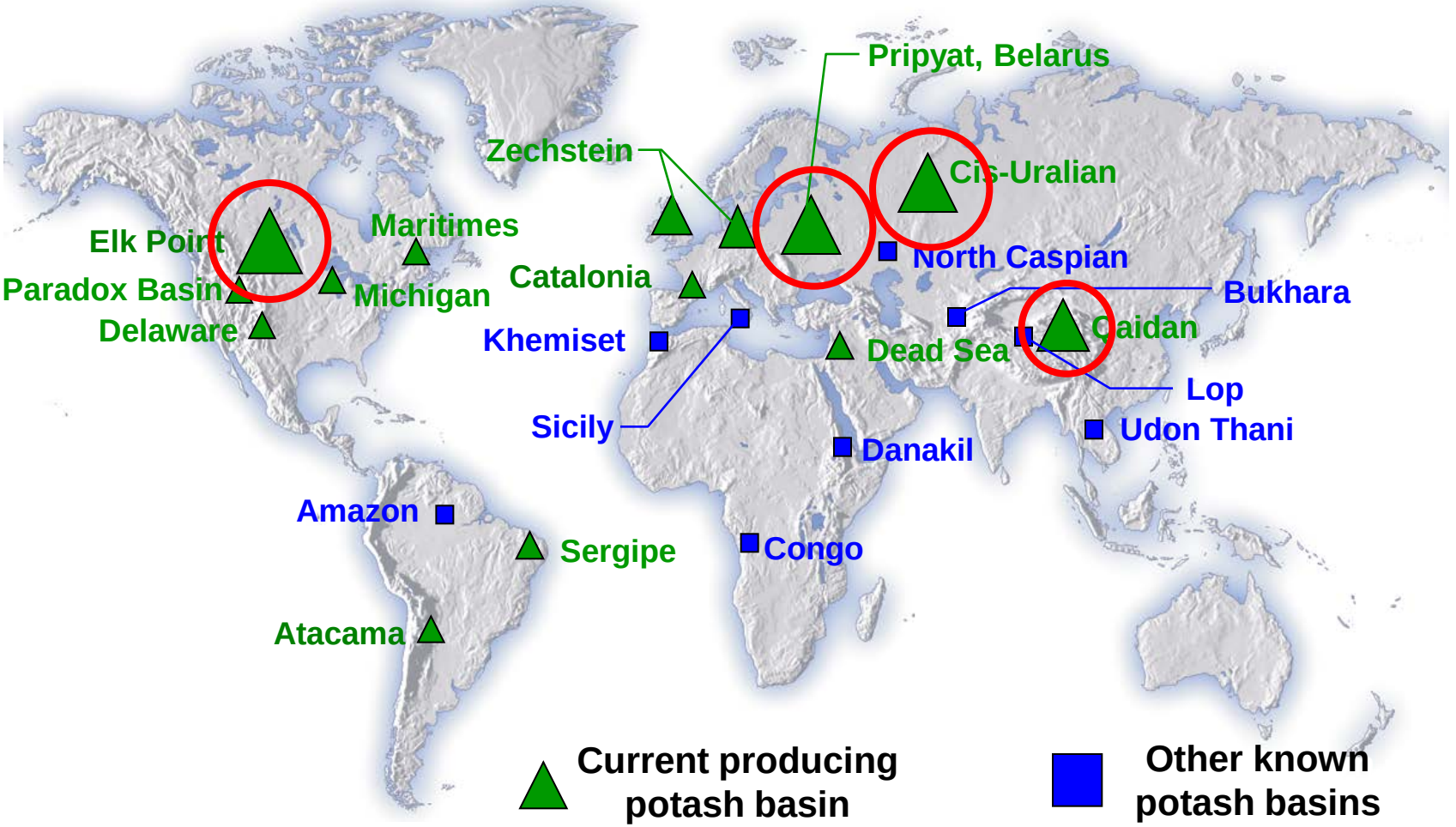


* Share of world's potash reserves; reserves as defined by the US Geological Survey
Other countries total 1 percent

Source: US Geological Survey

PCS 2014

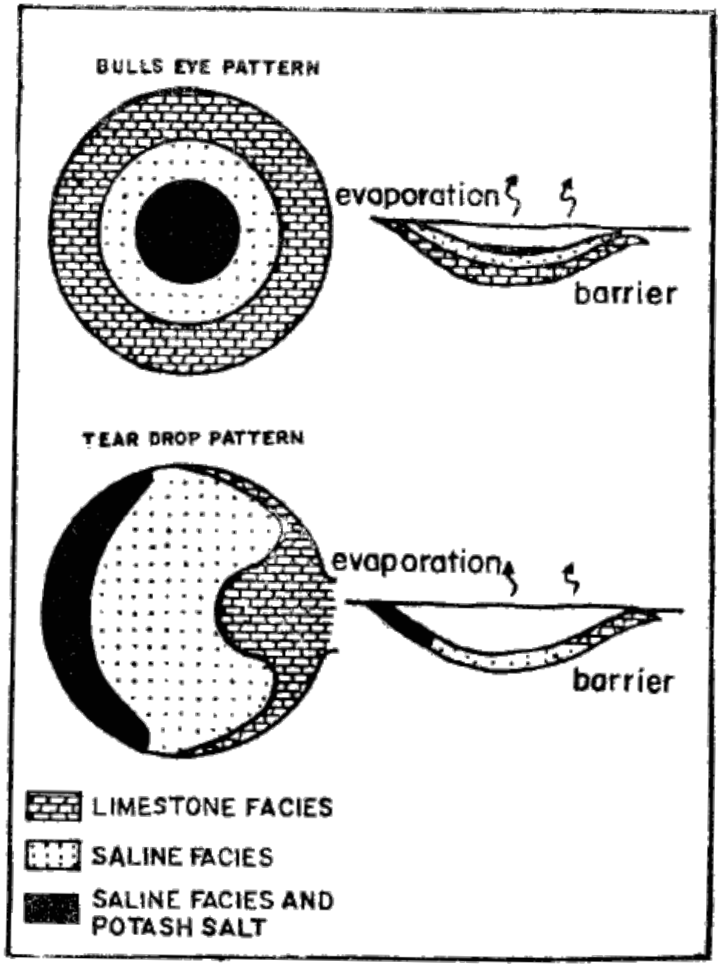
Where Potash - Production



How - Geological Setting

- Evaporite
- Barred basin – restricted infill
- Cycle – CO_3, SO_4, NaCl, Carnallite
  - dolomite, anhydrite, halite, sylvite
- Reflux – sea level
- Preservation – reduced shale (?cap)
- Stable tectonics – dissolution
- Deposits laterally continuous
  - +30km strike Carlsbad, NM

Basin Pattern Models

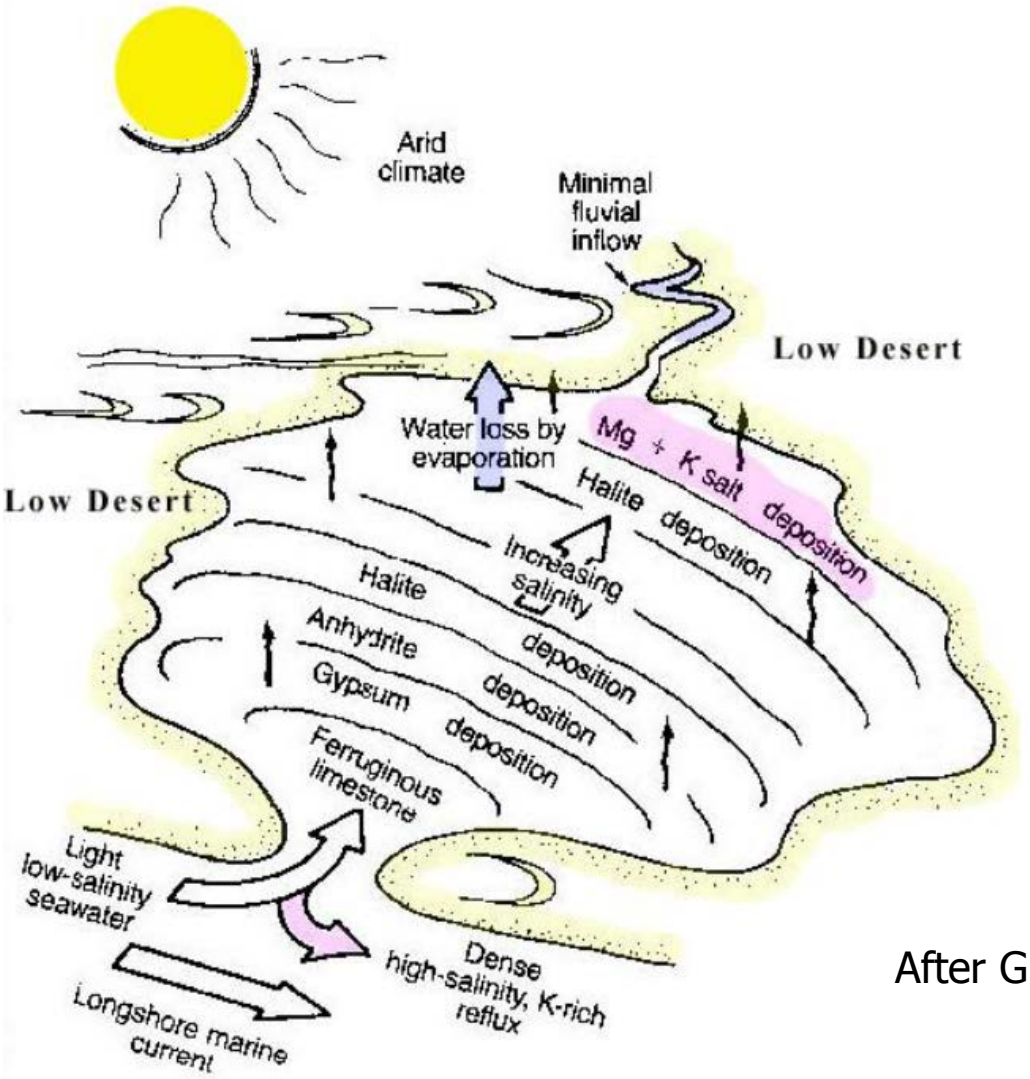


Closed Basin

Refluxing Basin

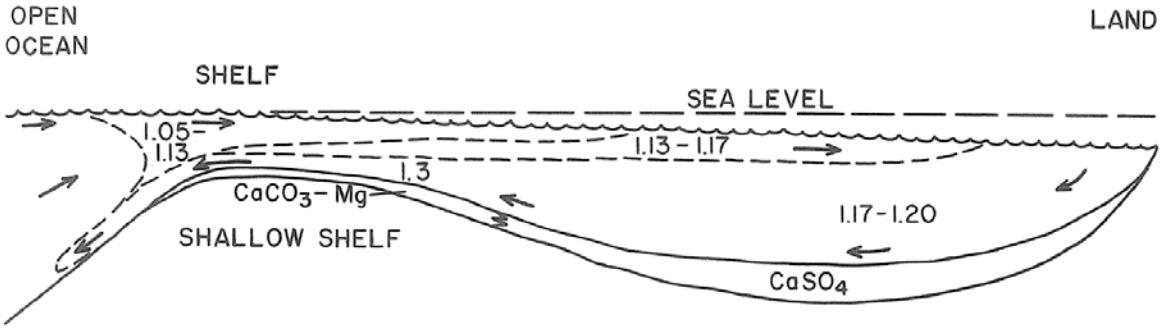
After Hsu, 1976

Basin Development

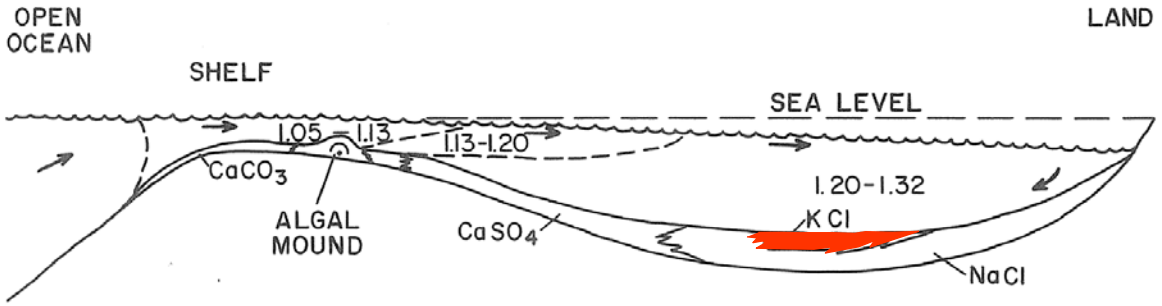


After Guilbert and Park, 1986

Barred Basin Model



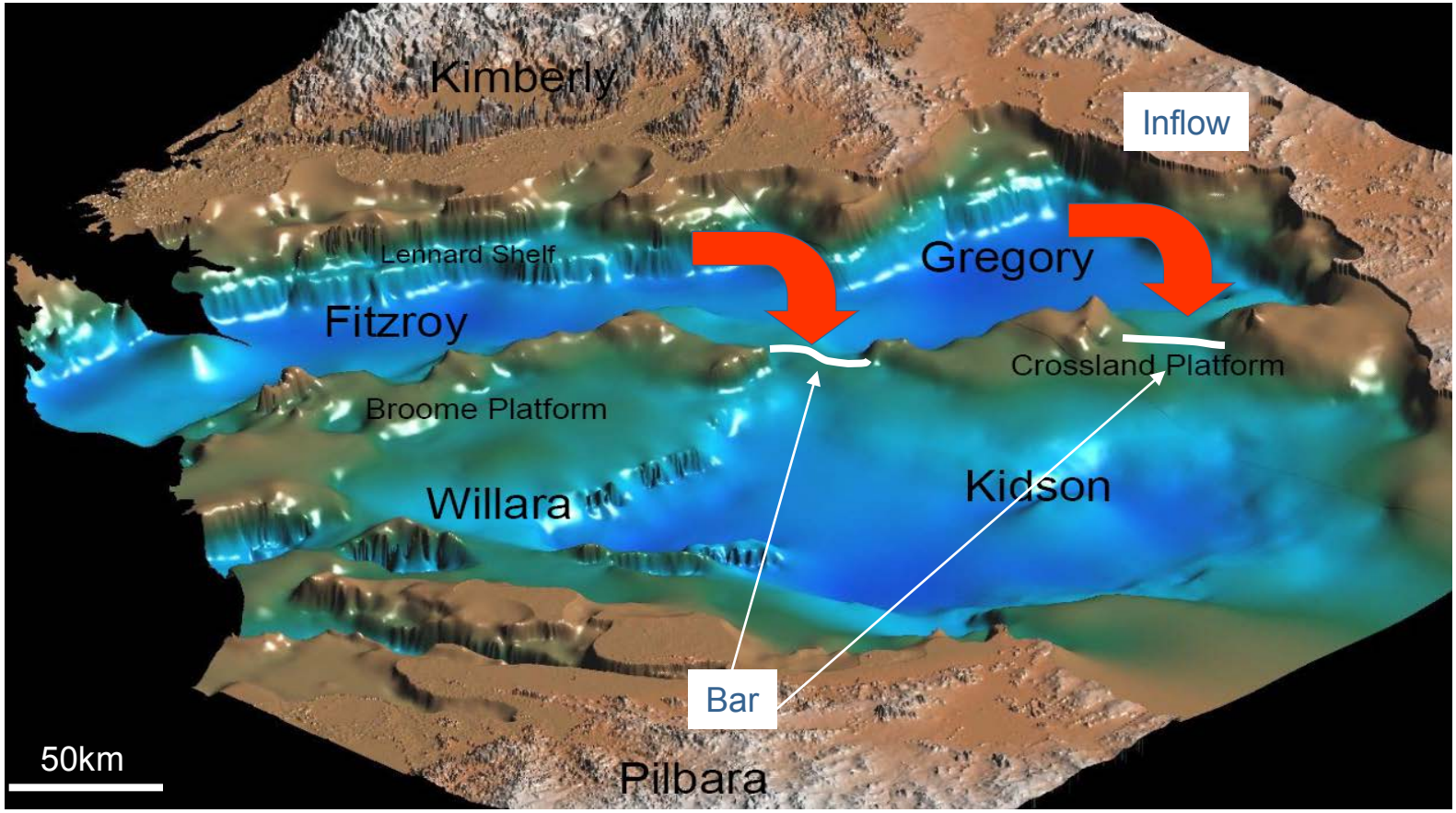
A. BASIN-TYPE EVAPORITE MODEL
TRANSGRESSIVE PHASE



B. BASIN-TYPE EVAPORITE MODEL
REGRESSIVE PHASE

Hite, 1983

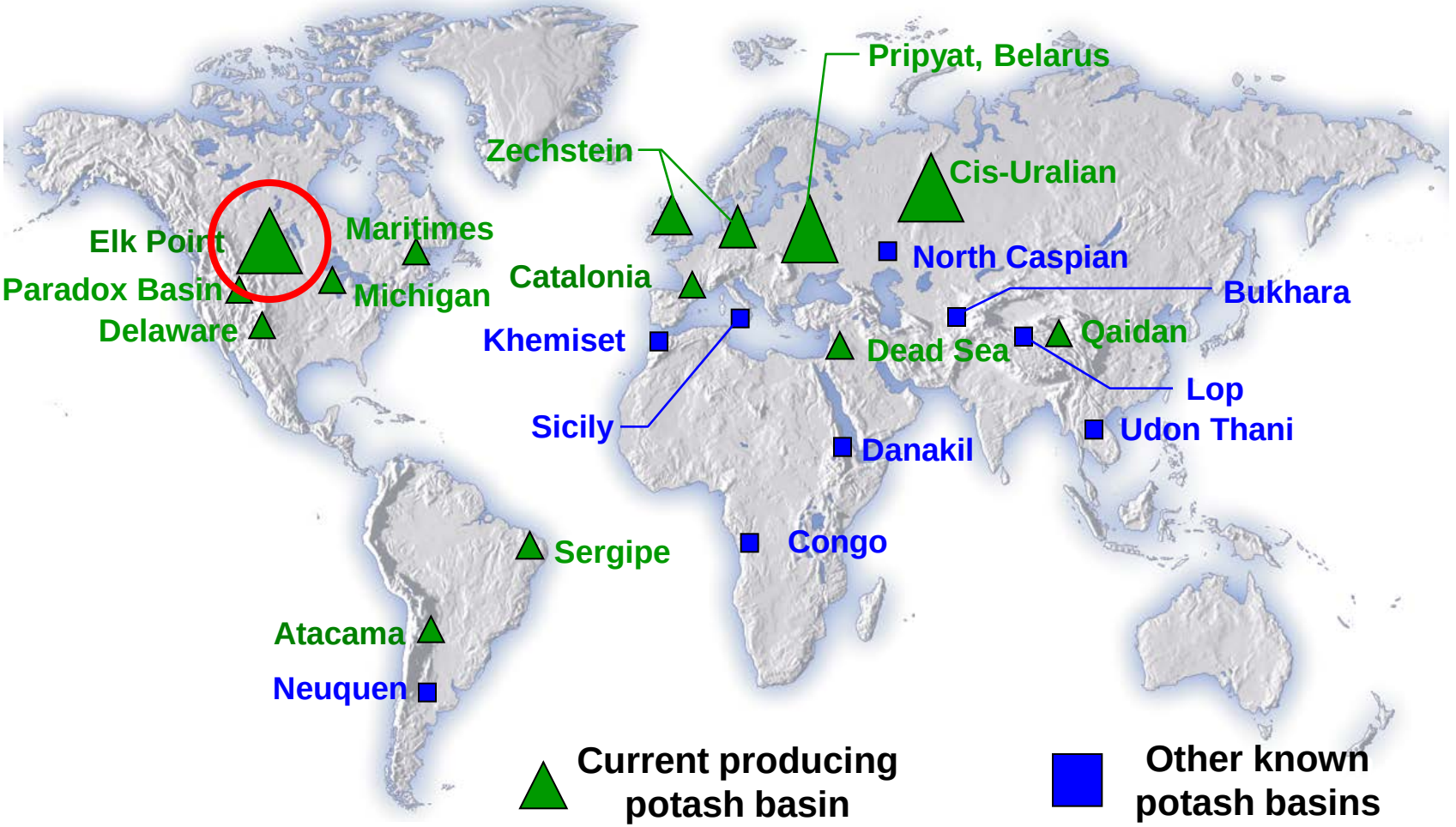
Canning Basin - SEEBASE

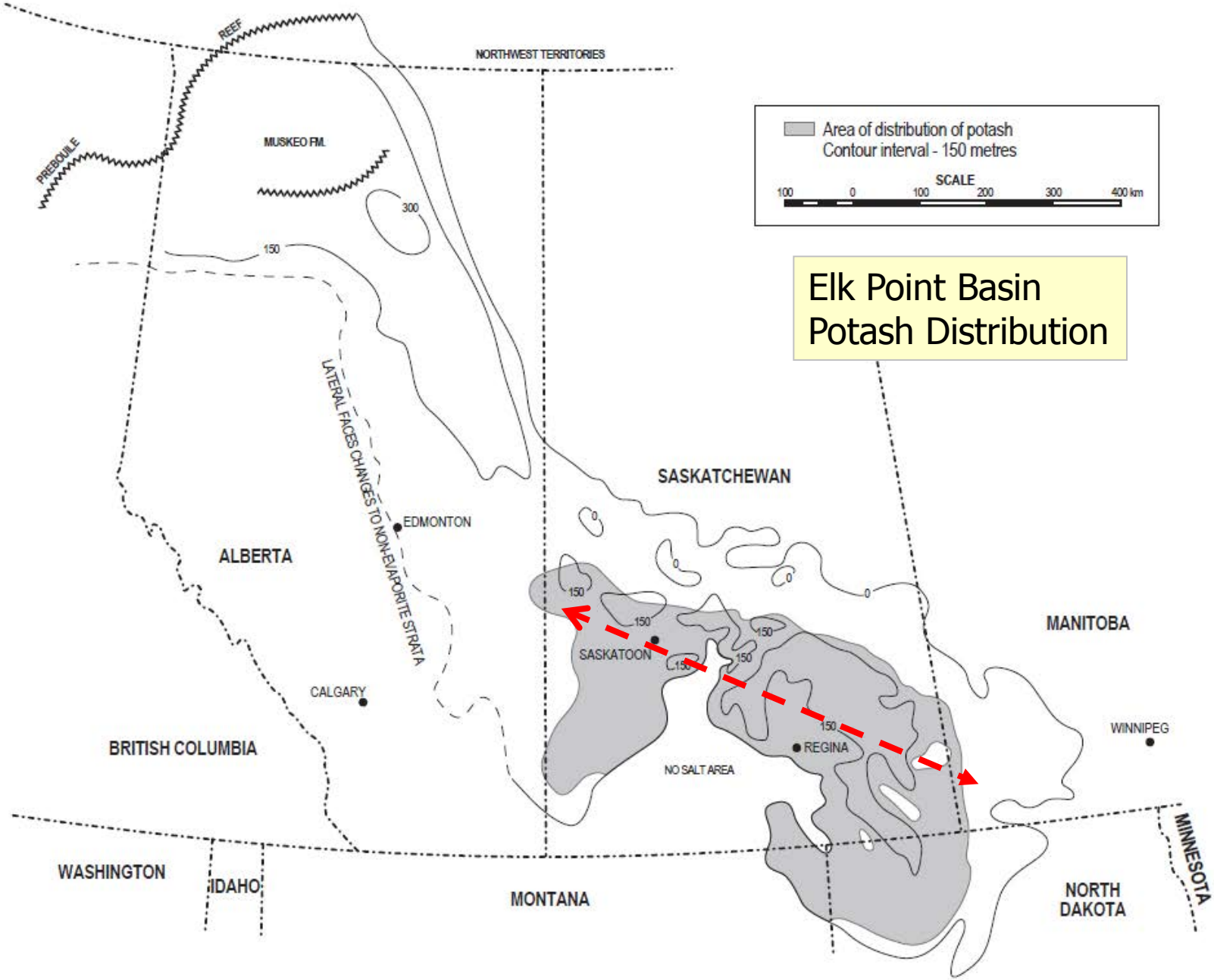


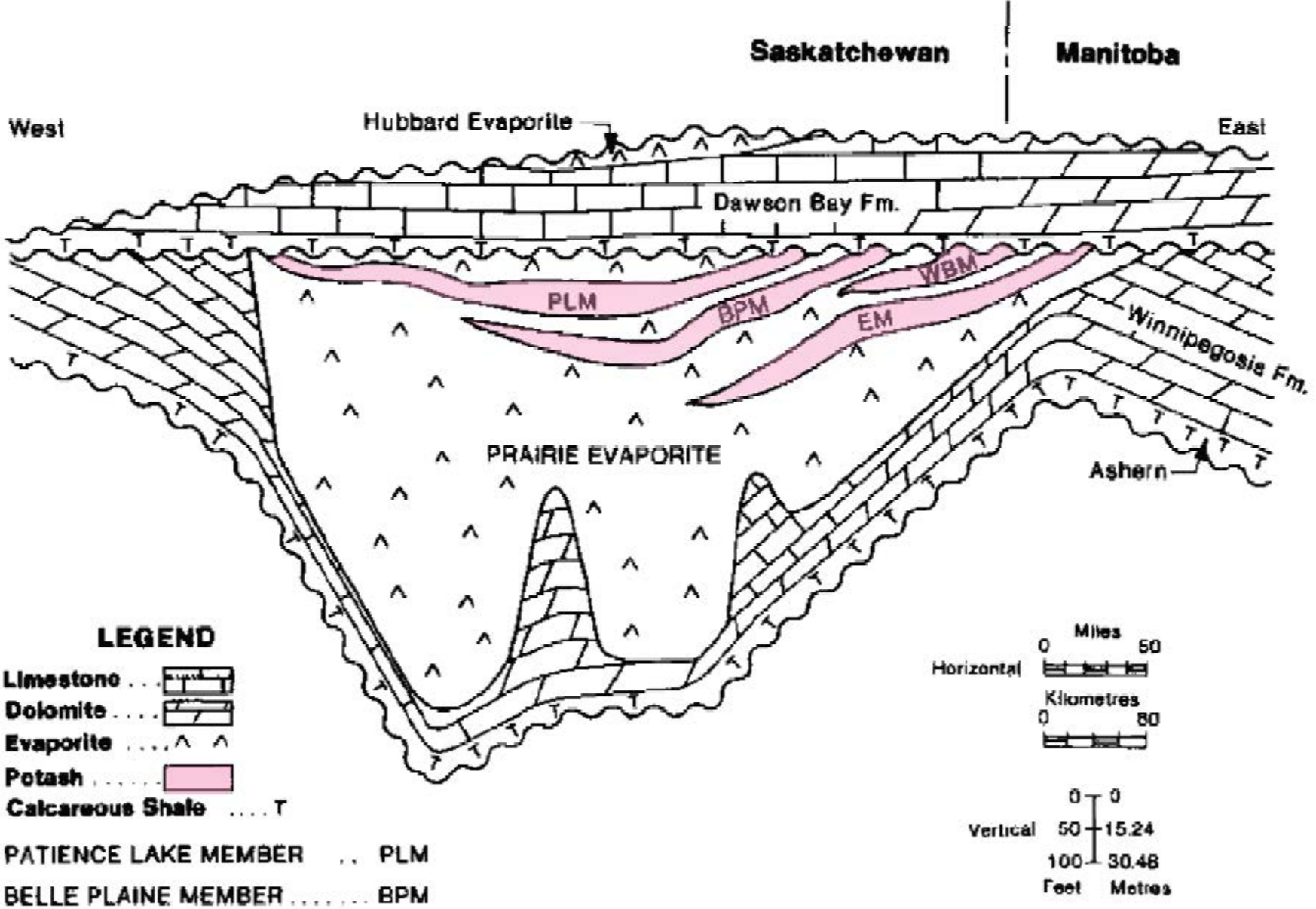
Mineralogy

	Mineral	Formula	% K_2O
Chlorides	*Sylvite*	*KCl*	*63*
	Carnallite	$MgCl_2.KCl.6H_2O$	17
	Kainite	$MgSO_4.KCl.3H_2O$	19
	"Sylvinite"	KCl.NaCl	~21
Sulphates	Polyhalite	$2CaSO_4.K_2SO_4.MgSO_4.2H_2O$	16
	Langbeinite	$MgSO_4.K_2SO_4$	23
	Anhydrite	$CaSO_4$	0

Elk Point Basin, Canada




Area of distribution of potash
Contour interval - 150 metres
SCALE
100 0 100 200 300 400 km
Elk Point Basin
Potash Distribution
REEF
PREEQUILE
MUSKEO FM.
NORTHWEST TERRITORIES
300
150
LATERAL FACES CHANGES TO NON-EVAPORITE STRATA
EDMONTON
ALBERTA
SASKATCHEWAN
SASKATOON
CALGARY
BRITISH COLUMBIA
MANITOBA
WINNIPEG
REGINA
NO SALT AREA
WASHINGTON
IDAHO
MONTANA
NORTH DAKOTA
MINNESOTA

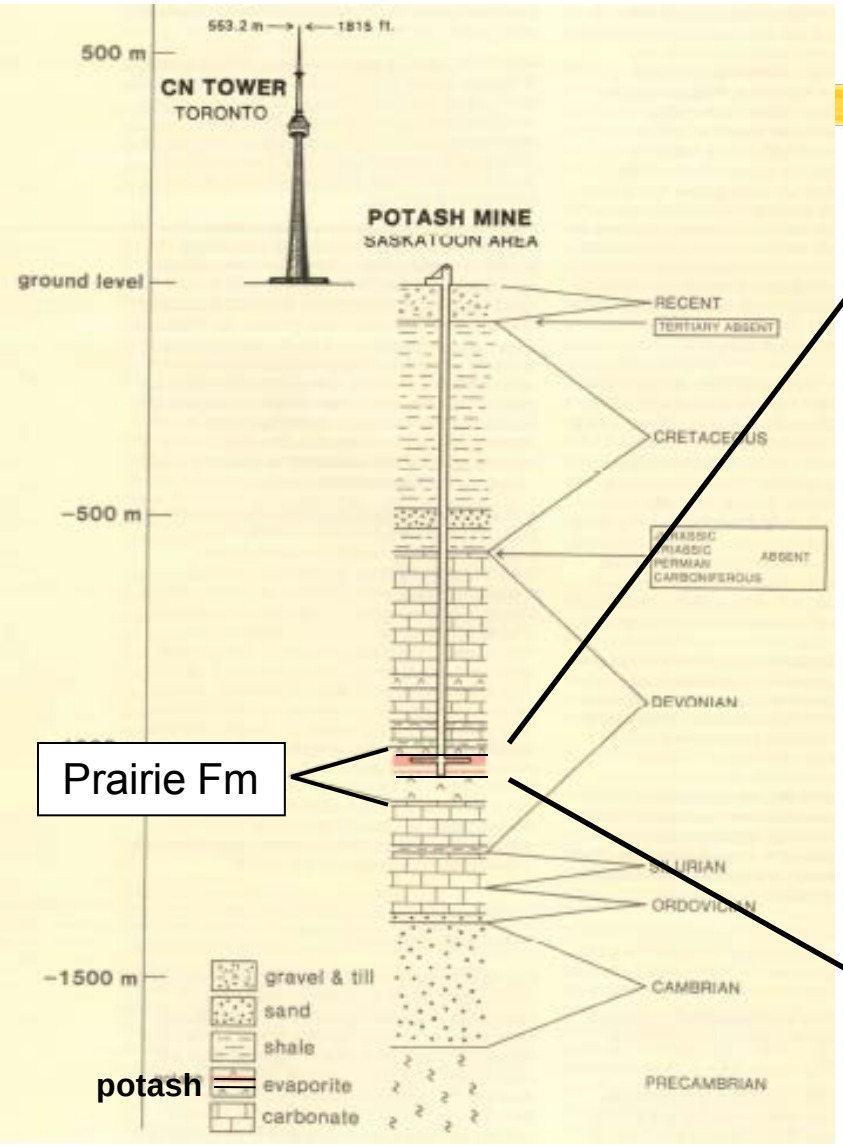


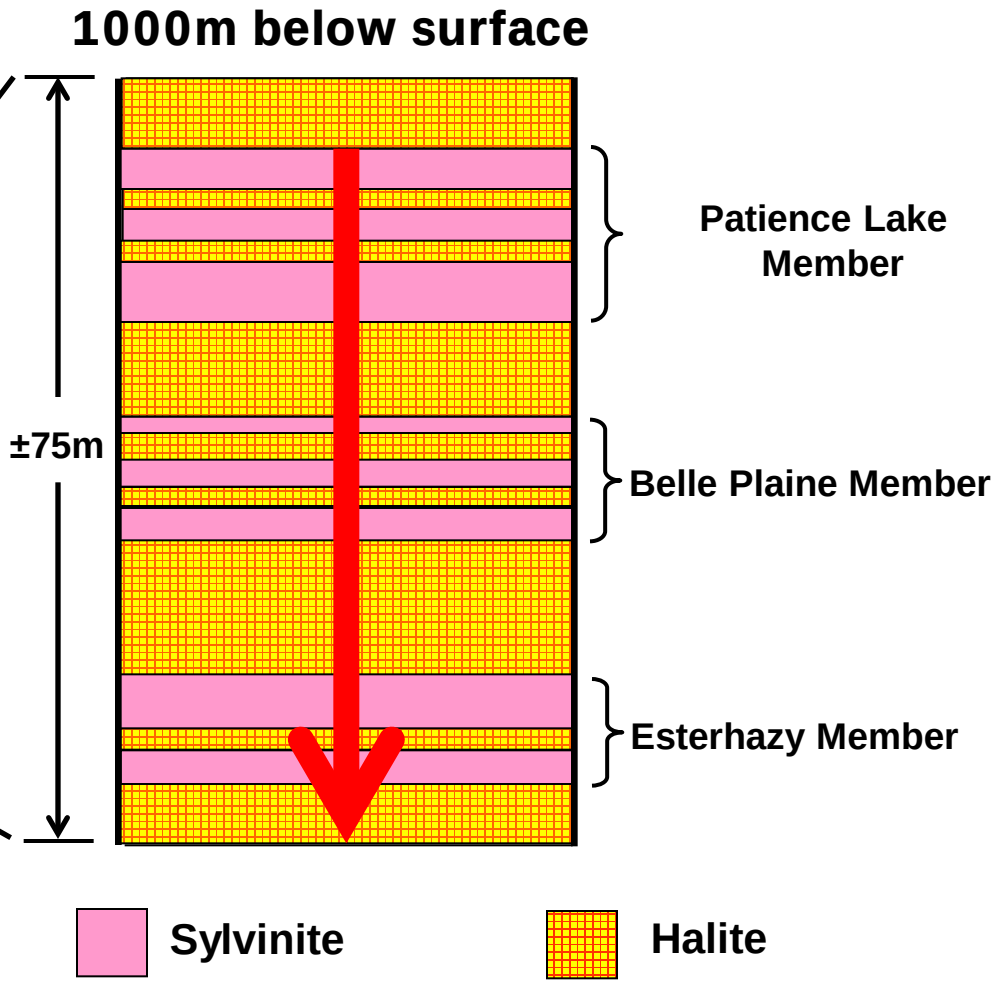
Adapted from Fuzesy, Anne, 1982: *Potash in Saskatchewan*; Saskatchewan Energy and Mines Report 181, pg. 9.

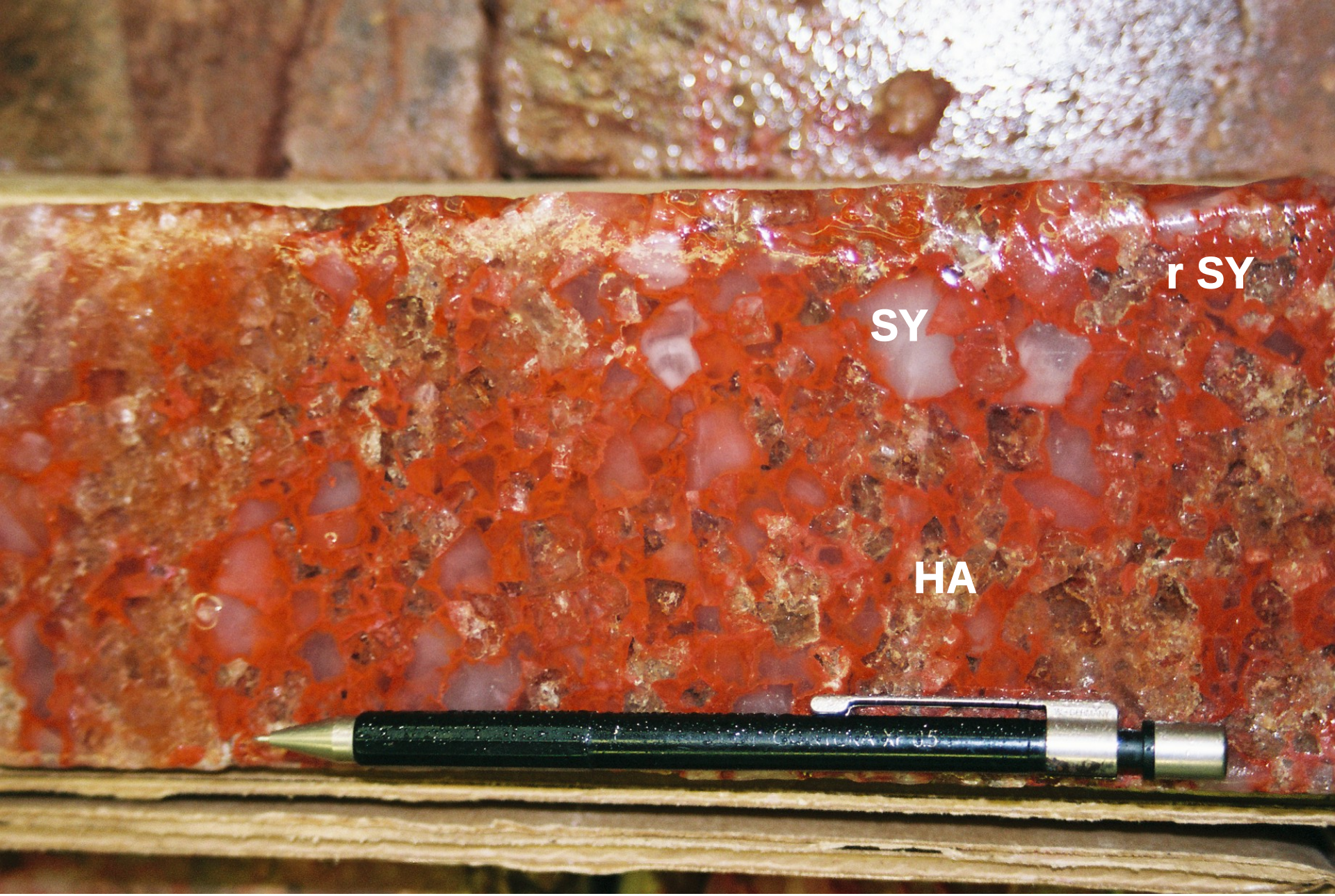
Elk Point Basin

- Geology
  - Winnipegosis - dolomite
  - Mid Dev – Prairie Evaporite
    - Lower Ha-An
    - Three main potash bearing units
      - PLM, BPM, EM (max +30m)
  - Second Red Bed
    - Shales – dolomitic; R G A

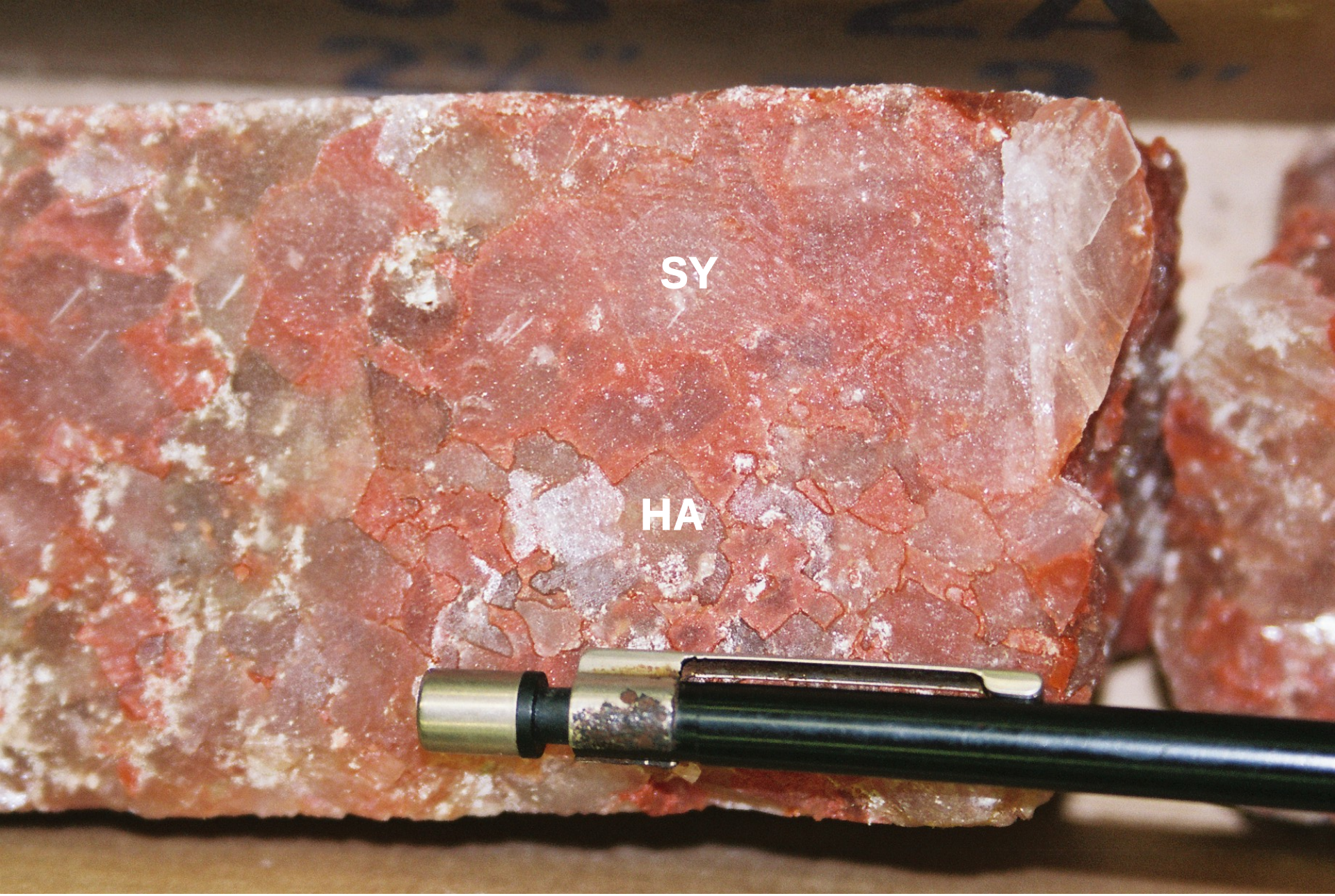
Prairie Evaporite







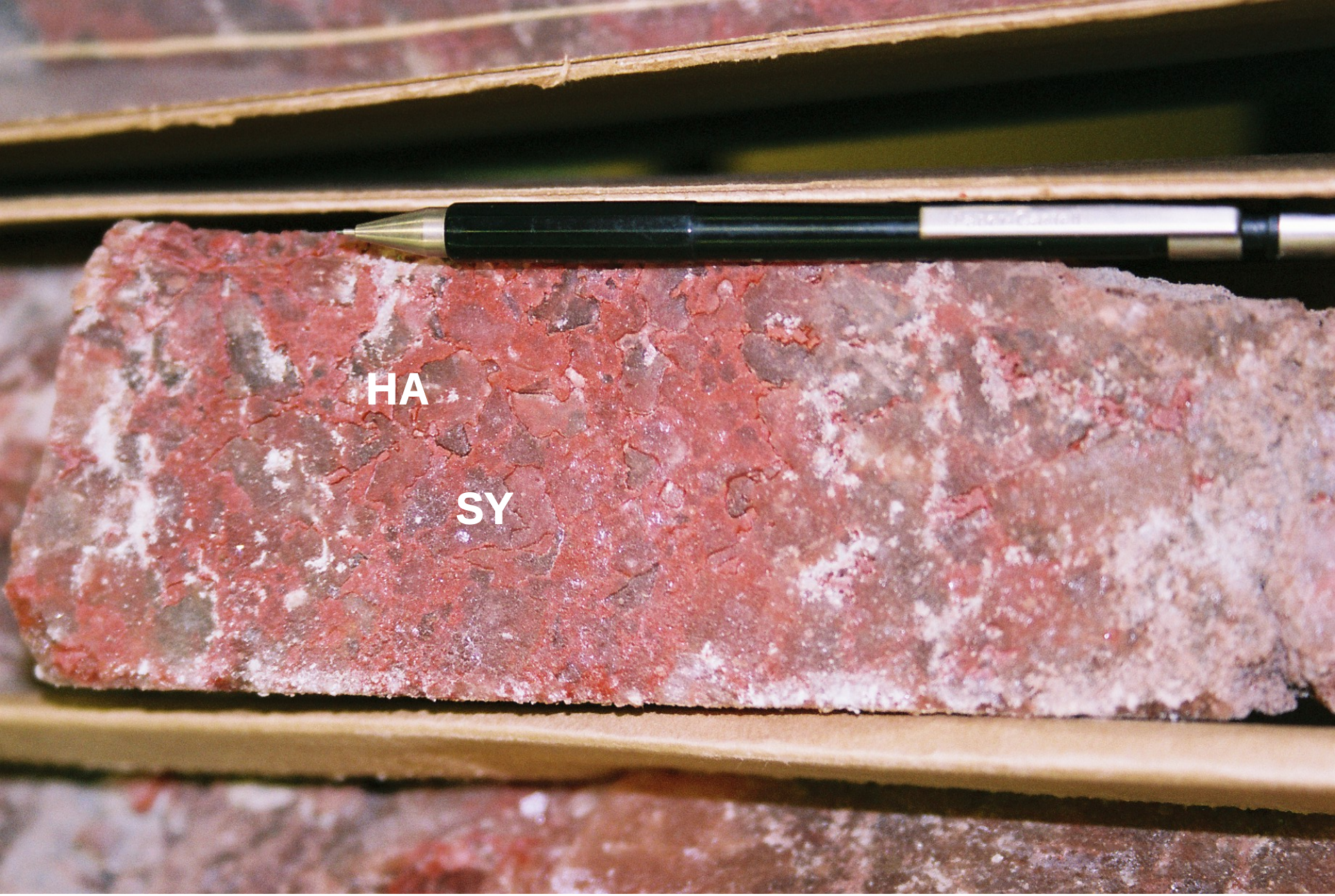
PLM – Lanigan



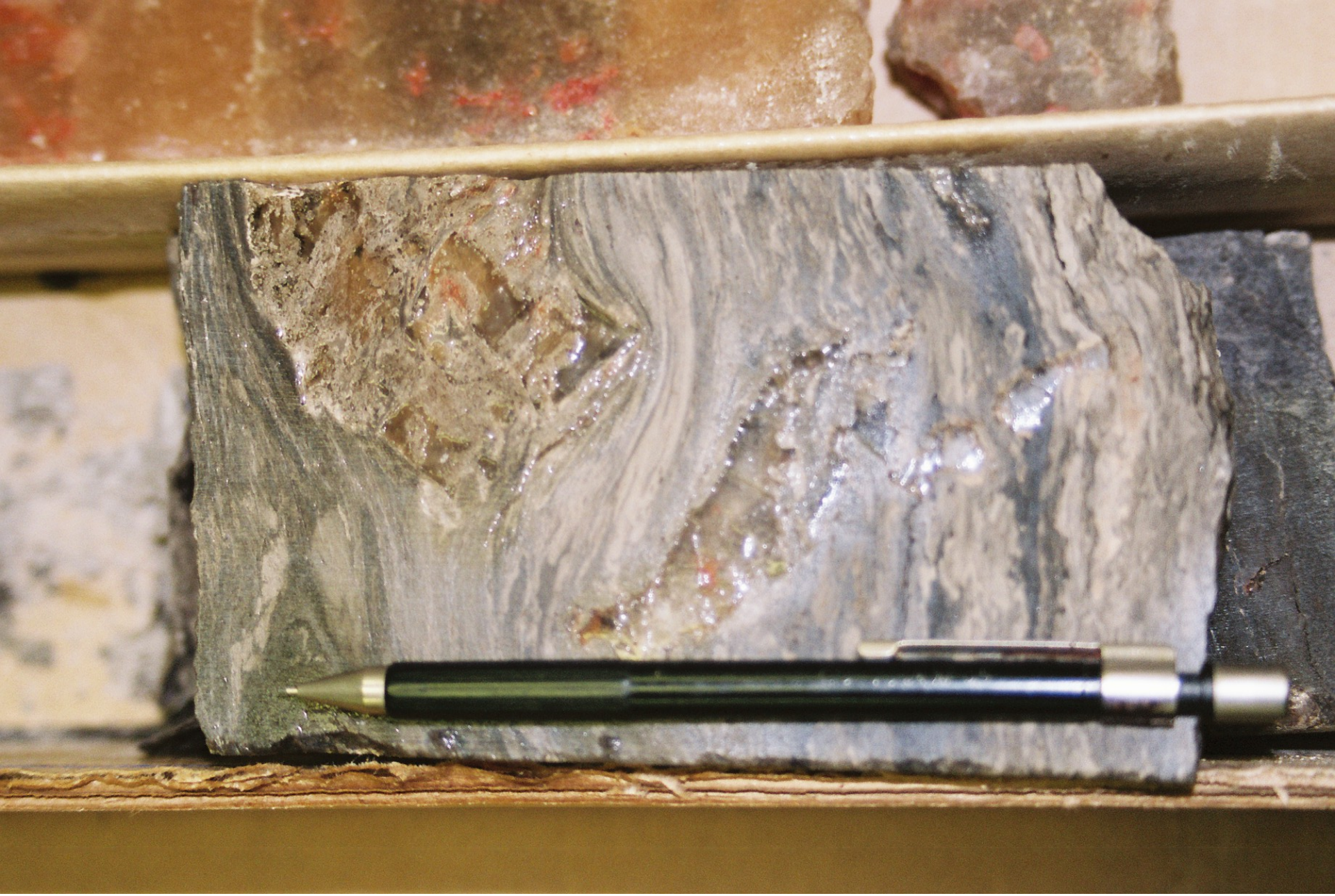
BPM - Lumsden

AN - ↓BPM

MX HA, mr SY



EM - Lumsden

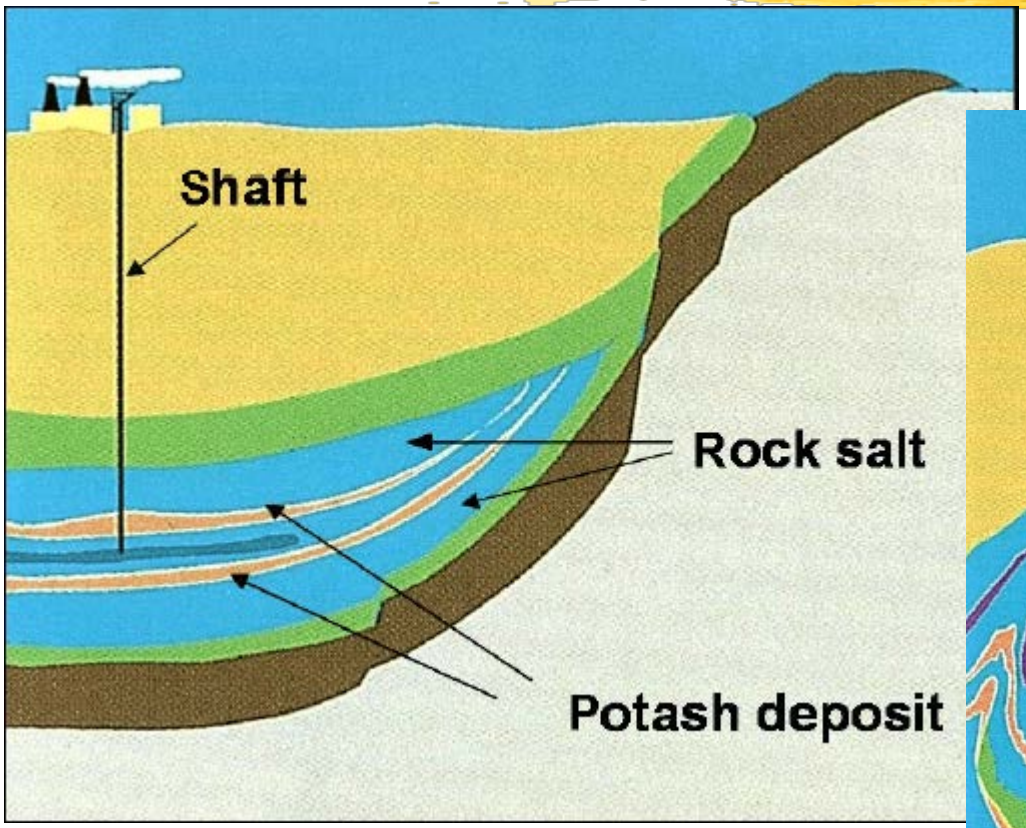


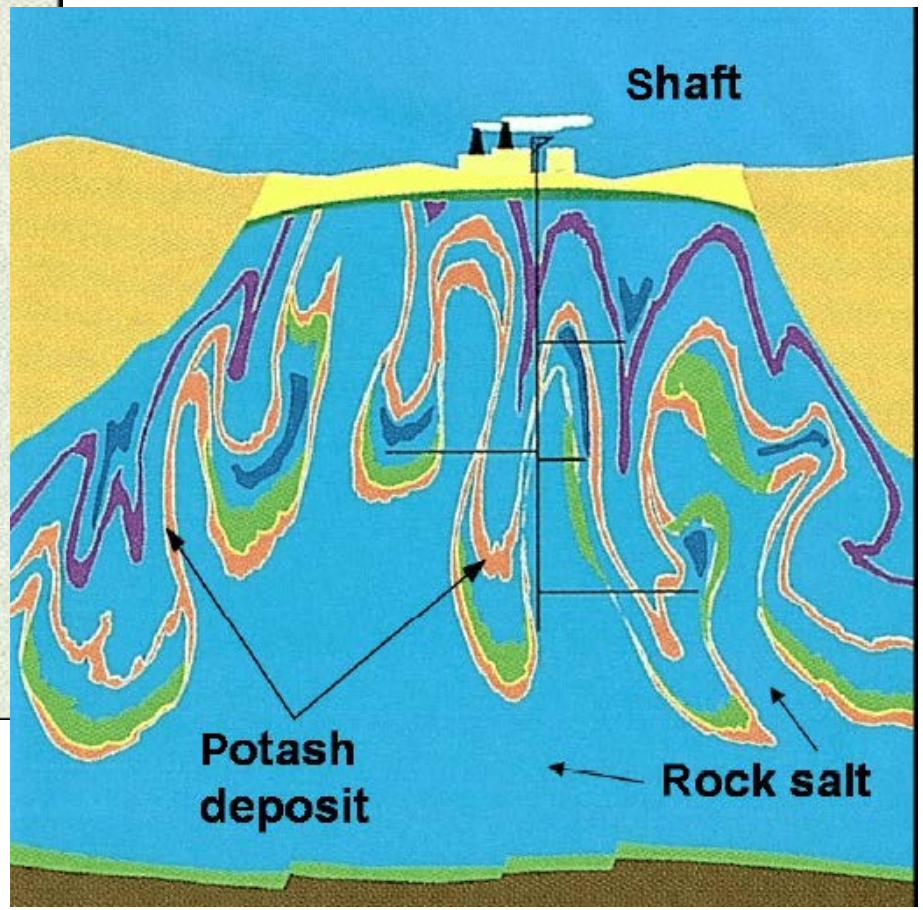
AN, cg HA, CY

CA $MgCl_2.KCl.6H_2O$

INsol

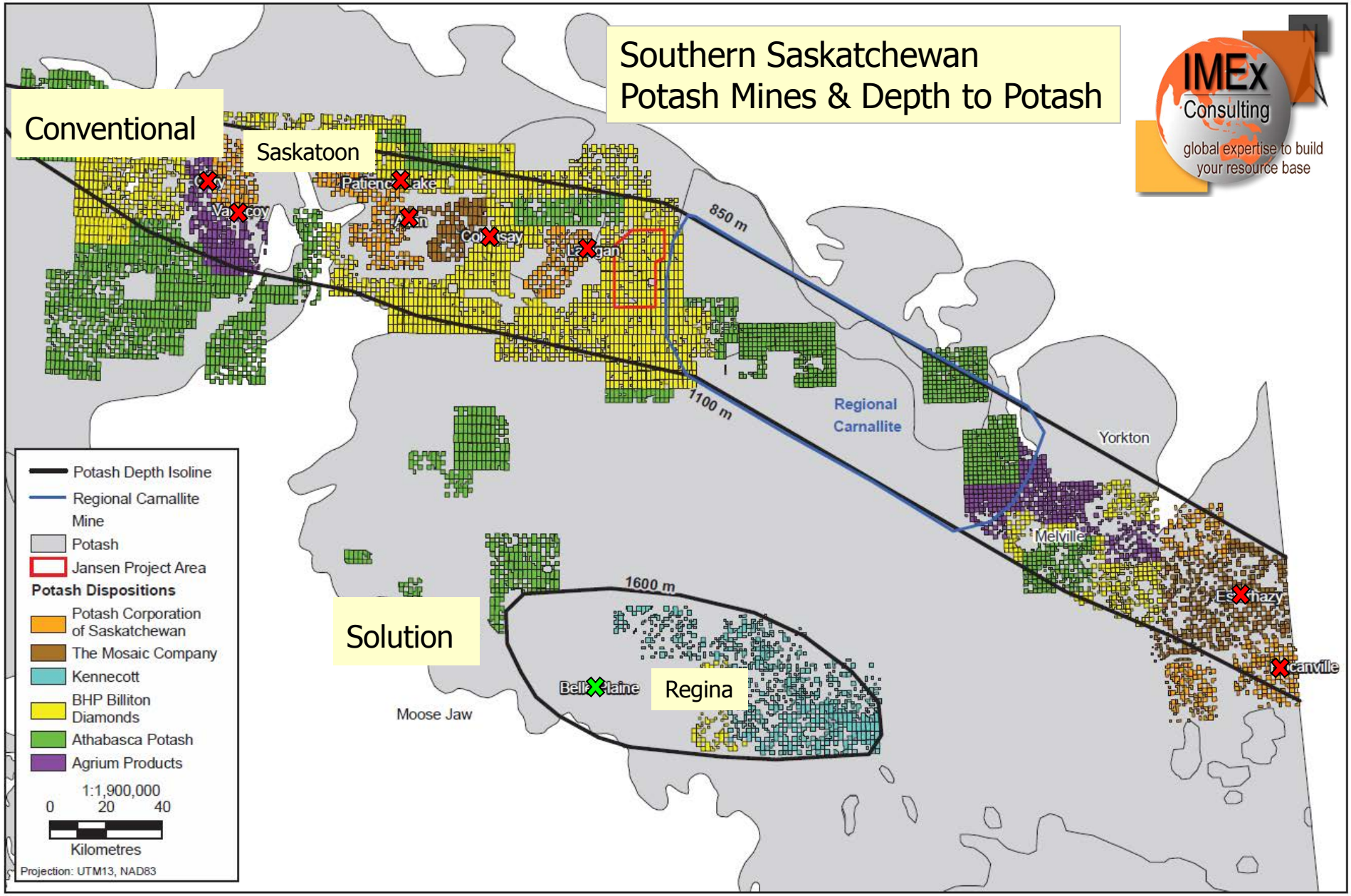
Zechstein Style





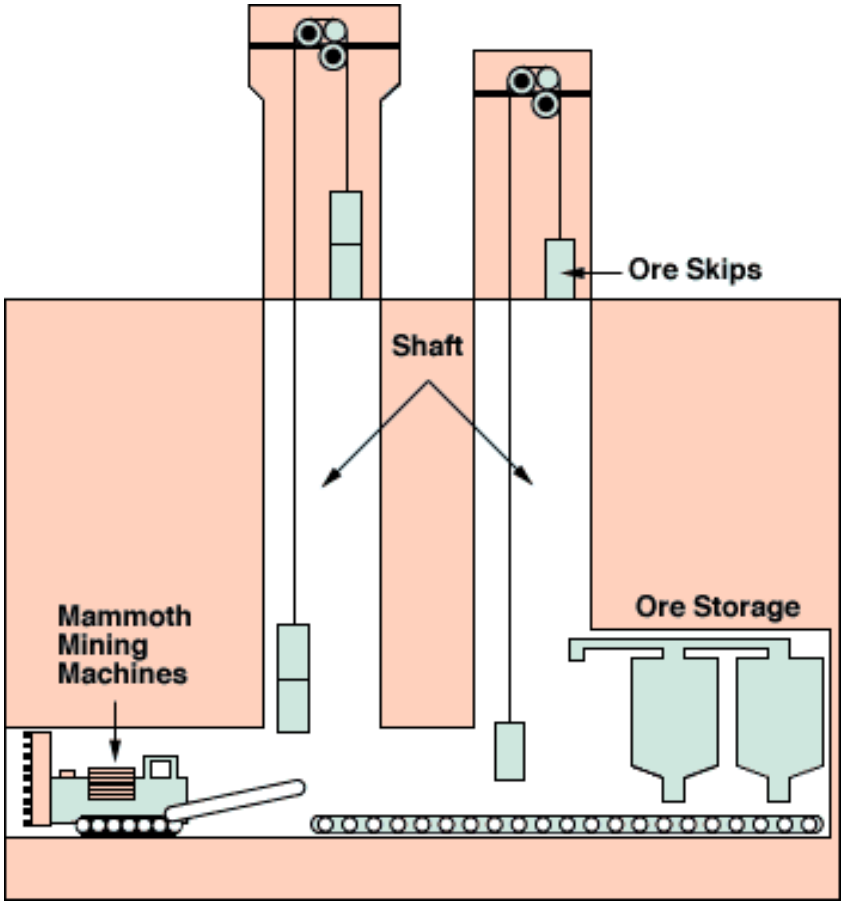
Potash Mining

- Solar : Dead Sea, Utah, Chile, China
- Underground : Conventional & Solution
  - Conventional : Room & Pillar <1200m
    - Saskatoon, SK, Canada
  - Solution: 300 - ~2,000m
    - Regina, SK, Canada


Southern Saskatchewan
Potash Mines & Depth to Potash
Conventional
Saskatoon
Solution
Regina
Moose Jaw
Yorkton
Melville
850 m
1100 m
1600 m
Regional
Carnallite
Potash Depth Isoline
Regional Carnallite
Mine
Potash
Jansen Project Area
Potash Dispositions
Potash Corporation of Saskatchewan
The Mosaic Company
Kennecott
BHP Billiton Diamonds
Athabasca Potash
Agrium Products
1:1,900,000
0 20 40
Kilometres
Projection: UTM13, NAD83
IMEx Consulting
global expertise to build your resource base

Conventional Mining

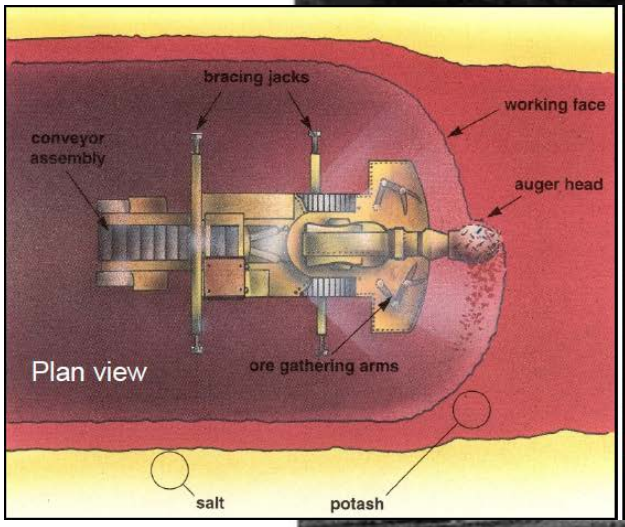
- Depth : 300m - 1200m
- Thick : 120m - >150m
- Room & Pillar - 5-12m high; 10-20m wide;
- 70% recovery (30% pillar)
- Drill & Blast, road headers or continuous miners
- Salt : 30cm bottom; 1-2m roof
- Prairie Evaporite
  - Strong impermeable rock 10-15m above
  - Not shale, sand, etc.

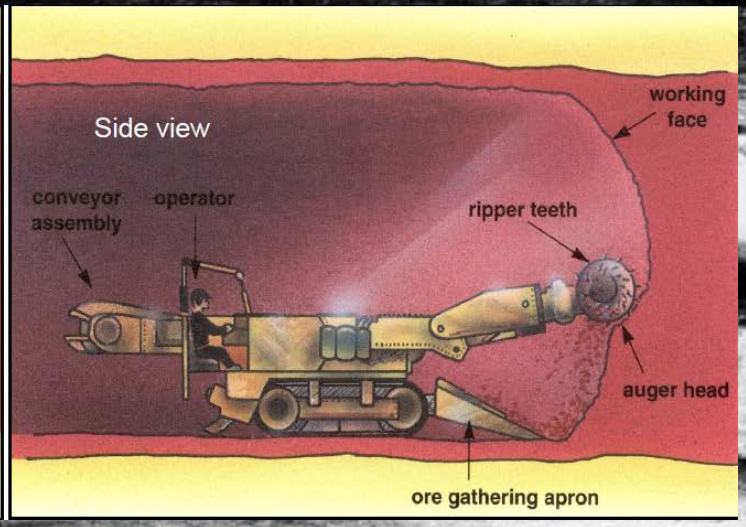


Room & Pillar

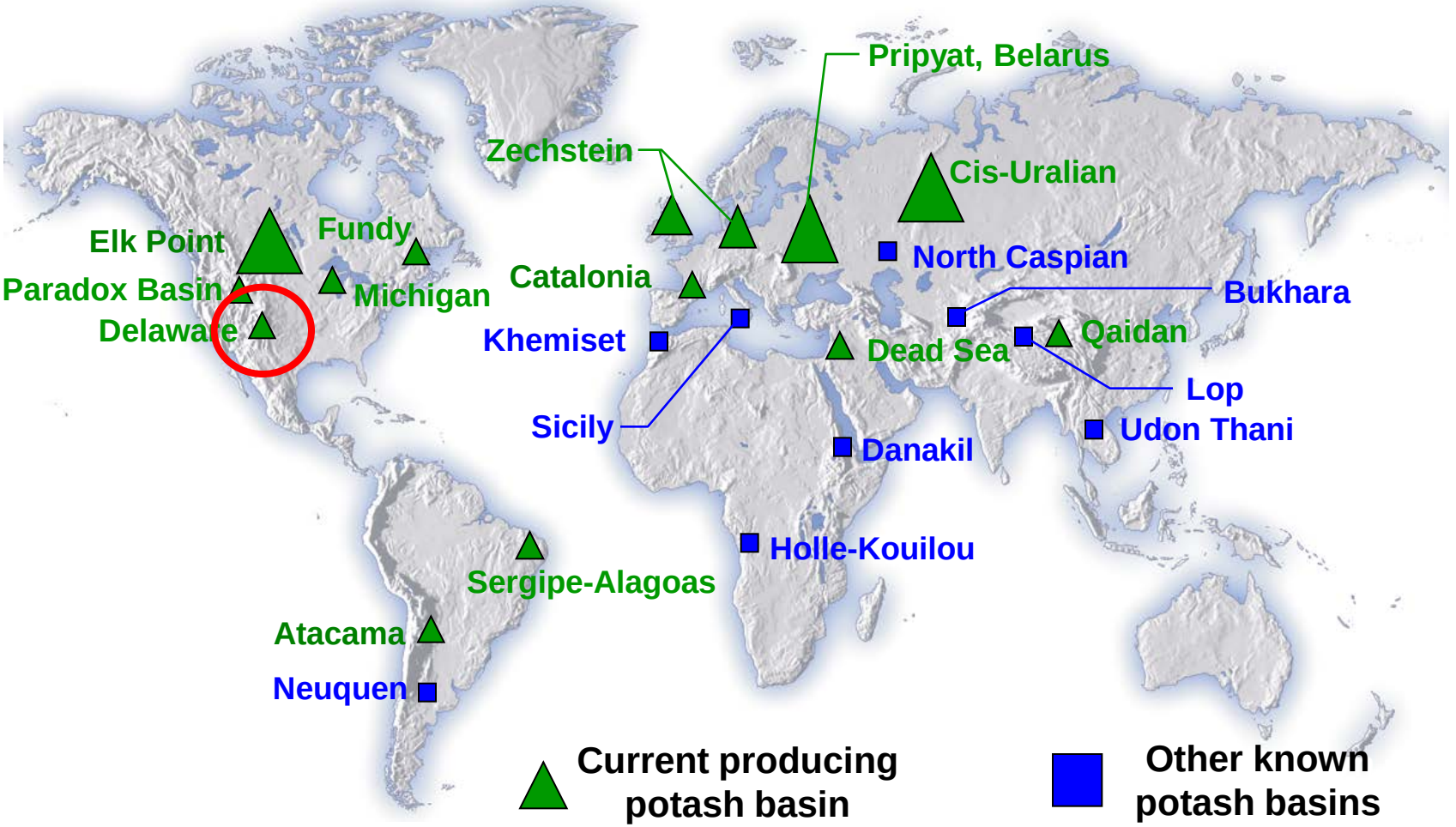
Vanscoy, Sk

Conventional Mining



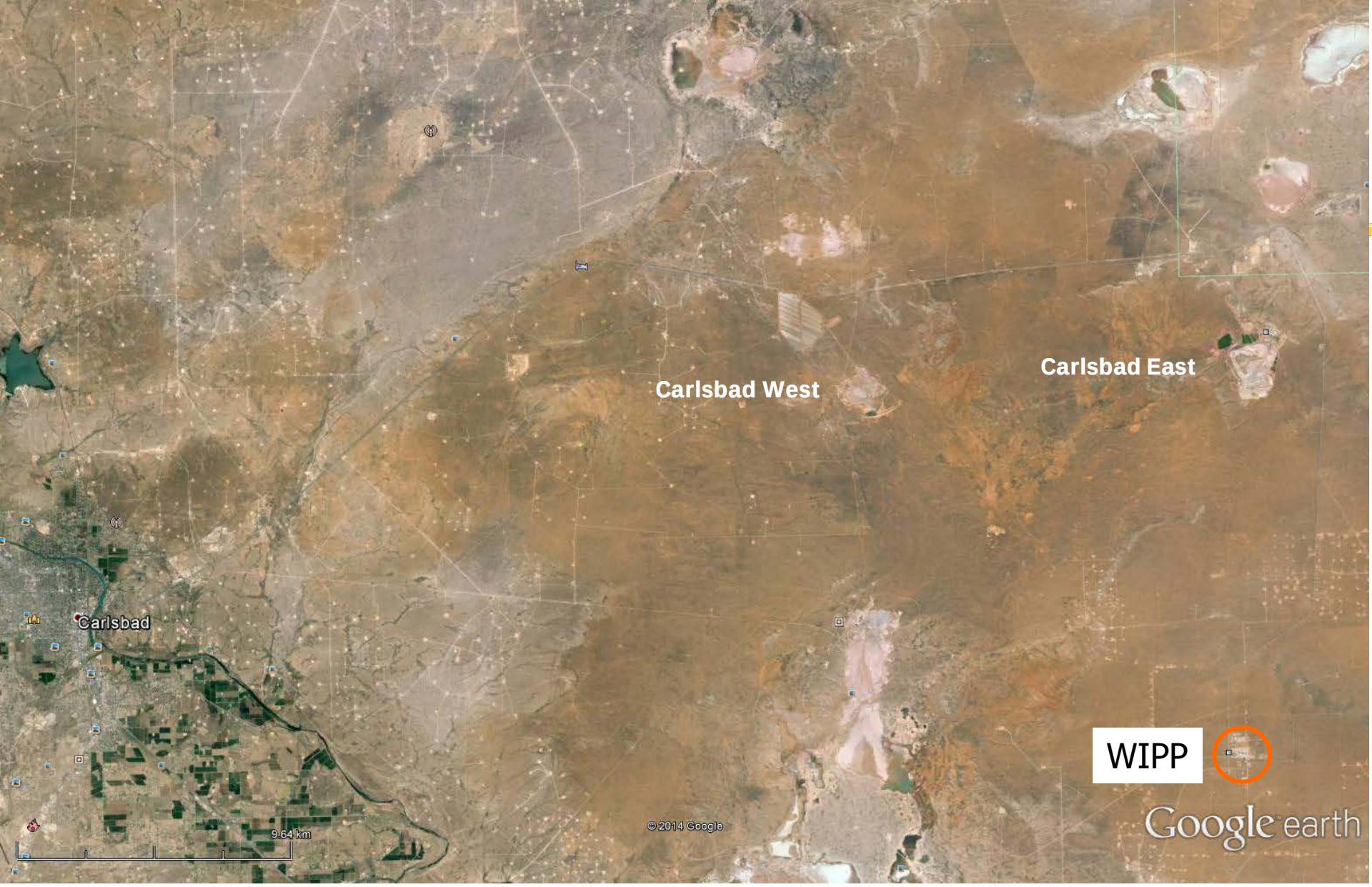


Delaware Basin, New Mexico

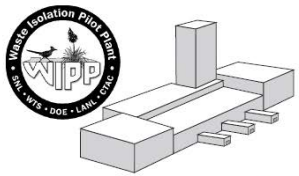



NEW MEXICO
INTREPID POTASH
Carlsbad
Railroad
0 40 mi
©1997 MAGELLAN Geographix
(805) 685-3100 www.maps.com
Cortez
MESA VERDE
UTAH NATIONAL PARK
Durango
Pagosa Springs
Antonito
Trinidad
COLORADO
ARIZONA
Shiprock
Navajo Reservoir
Farmington
Tierra Amarilla
Raton
Des Moines
Clayton
TEXAS
Taos
Springer
Dalhart
Los Alamos
Santa Fe
Window Rock
Gallup
Las Vegas
Logan
Bernalillo
Grants
Zuni
Albuquerque
Tucumcari
Santa Rosa
Belen
Vaughn
Fort Sumner
Clovis
Portales
Socorro
Alpine
Carrizozo
Gila River
Truth or Consequences
Silver City
Alamogordo
Artesia
WHITE SANDS NATIONAL MONUMENT
Hatch
Lordsburg
Deming
Las Cruces
CARLSBAD CAVERNS NATIONAL PARK
Carlsbad
Andrews
Rio Grande
El Paso
GUADALUPE MTS NATIONAL PARK
Monahans
Ciudad Juárez
MEXICO
Pecos


CARLSBAD


Carlsbad West
Carlsbad East
Carlsbad
WIPP
9.64 km
© 2014 Google
Google earth

Waste Isolation Pilot Plant



Why WIPP?

Transuranic, or TRU, waste began accumulating in the 1940s with the beginr the nation's nuclear defense program. As early as the 1950s, the National Aca of Sciences recommended deep-geologic disposal of TRU radioactive was stable formations, such as deep salt beds. Sound environmental practices anc regulations require such wastes to be isolated to protect human health ar environment.

WIPP is located in the Chihuahuan Desert, far from major population centers.

Bedded salt is free of fresh flowing water, easily n impermeable and geologically stable – an ideal m for permanently isolating long-lived radioactive w from the environment.

Throughout the 1960s, government scientists sea for an appropriate site for radioactive waste dis eventually testing a remote desert area of southea New Mexico where, 250 million years earlier, evapo cycles of the ancient Permian Sea had crea 2,000-foot-thick salt bed.

In 1979, Congress authorized the U.S. Departm Energy's (DOE) Waste Isolation Pilot Plant (WIPP) WIPP facility, located 26 miles southeast of Car N.M., was constructed during the 1980s. Cor limited WIPP to the disposal of defense-generatec wastes, prohibiting disposal of commercial, low-lev high-level radioactive wastes. In 1998, the U.S. Environmental Protection A (EPA) certified WIPP for safe, long-term disposal of TRU wastes.

Generally, TRU waste consists of clothing, tools, rags, residues, debris, sc other items contaminated with radioactive elements, mostly plutonium. man-made elements have atomic numbers greater than uranium, thus trans-u or beyond uranium on the Periodic Table of Elements.

There are two categories of TRU waste. Contact-handled (CH) TRU waste c handled by workers under controlled conditions without any shielding other th container itself. CH TRU waste will account for approximately 96 percent of th volume of waste to be disposed at WIPP. The remaining four percent will be re handled TRU waste, which emits more penetrating radiation than CH-TRU and must be handled and transported in lead-shielded casks.

Prime regulators at WIPP are the EPA and the New Mexico Environment Department. A number of other agencies, committees and panels monitor WIPP progress and contribute to project success.

The DOE Carlsbad Field Office, which leads the nation's TRU waste disposal effort, has coordinated TRU waste cleanup at a number of generator sites around the country. Since 1999, WIPP has set the standard for safe, permanent disposal of long-lived radioactive defense wastes.

Did you know

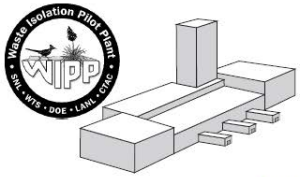
WIPP's disposal rooms are nearly half mile below t surface (2,150 fe By comparison, t Empire State Building is only 1,454 feet high.

For more information

WIPP Information Center
U.S. Department of Energy
Carlsbad Field Office
P.O. Box 2078
Carlsbad, NM 88221

1-800-336-WIPP (9477)
E-mail: infocntr@wipp.ws
Web address: www.wipp.energy.gov

Updated: February 5, 2007



WIPP Chronology

1957 The National Academy of Sciences concludes that the most promising method of disposal of radioactive waste is in salt deposits.

1974 The U.S. Atomic Energy Commission (AEC) chooses an ancient salt bed 26 miles east of Carlsbad for exploratory work in the search for an underground radioactive waste repository site.

First receipt of waste at WIPP on March 26, 1999.

1979 Congress authorizes WIPP as a research and development facility to demonstrate the safe disposal of radioactive waste from defense activities not regulated by the U.S. Nuclear Regulatory Commission (NRC).

1981 The U.S. Department of Energy (DOE), formerly the AEC, issues a record of decision based on an environmental impact statement to proceed with WIPP construction, and the first exploratory shaft is drilled. New Mexico Attorney General Jeff Bingaman files a lawsuit in federal court against the U.S. Department of the Interior (DOI), which has jurisdiction of the land where WIPP is located, and DOE, alleging violations of federal and state law. The lawsuit is settled by an agreement for more study and communication with the state, as well as addressing concerns such as emergency response and highway improvements.

Did you know ...

Underground excavation at WIPP began in 1982.

1985 The U.S. Environmental Protection Agency (EPA) establishes radioactive waste disposal regulations specifically addressing transuranic (TRU) waste and WIPP, after DOE and the state of New Mexico agree WIPP must comply with EPA regulations.

1989 NRC certifies DOE's main contact-handled (CH) TRU waste shipping cask, the Transuranic Packaging Transporter Model 2 (TRUPACT-II). DOE completes repository construction.

1990 DOE issues a record of decision based on a supplemental environmental impact statement to continue with phased development of WIPP. EPA authorizes the state of New Mexico to issue and enforce a hazardous waste facility permit under the federal Resource Conservation and Recovery Act (RCRA) for disposal of waste that includes hazardous materials such as solvents or metals (mixed waste).

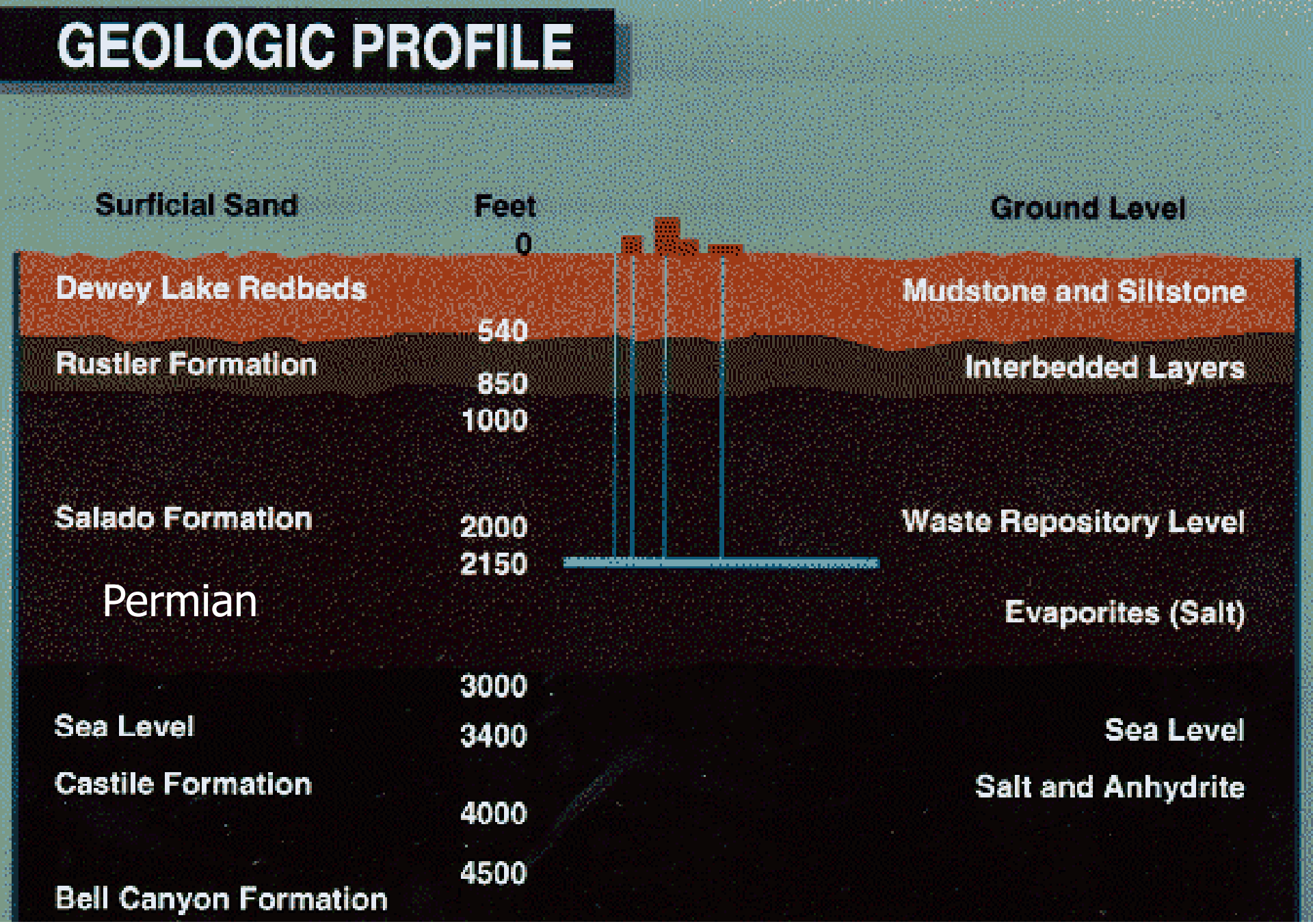
1991 New Mexico Attorney General Tom Udall files a federal lawsuit against DOE and DOI regarding the withdrawal of land from public use for a WIPP testing phase. The lawsuit is later combined with another brought by several environmental groups alleging WIPP lacks interim status under RCRA that would allow WIPP to be treated as if a hazardous waste facility permit had been issued.

1992 U.S. District Judge John Garrett Penn imposes an injunction, ruling the Interior Secretary exceeded his authority by changing the purpose of the land withdrawal from construction to testing, which includes transporting waste to WIPP. President Bush signs into law the WIPP Land Withdrawal Act, which transfers


139
139
138
138
Waste Isolation Pilot Plant

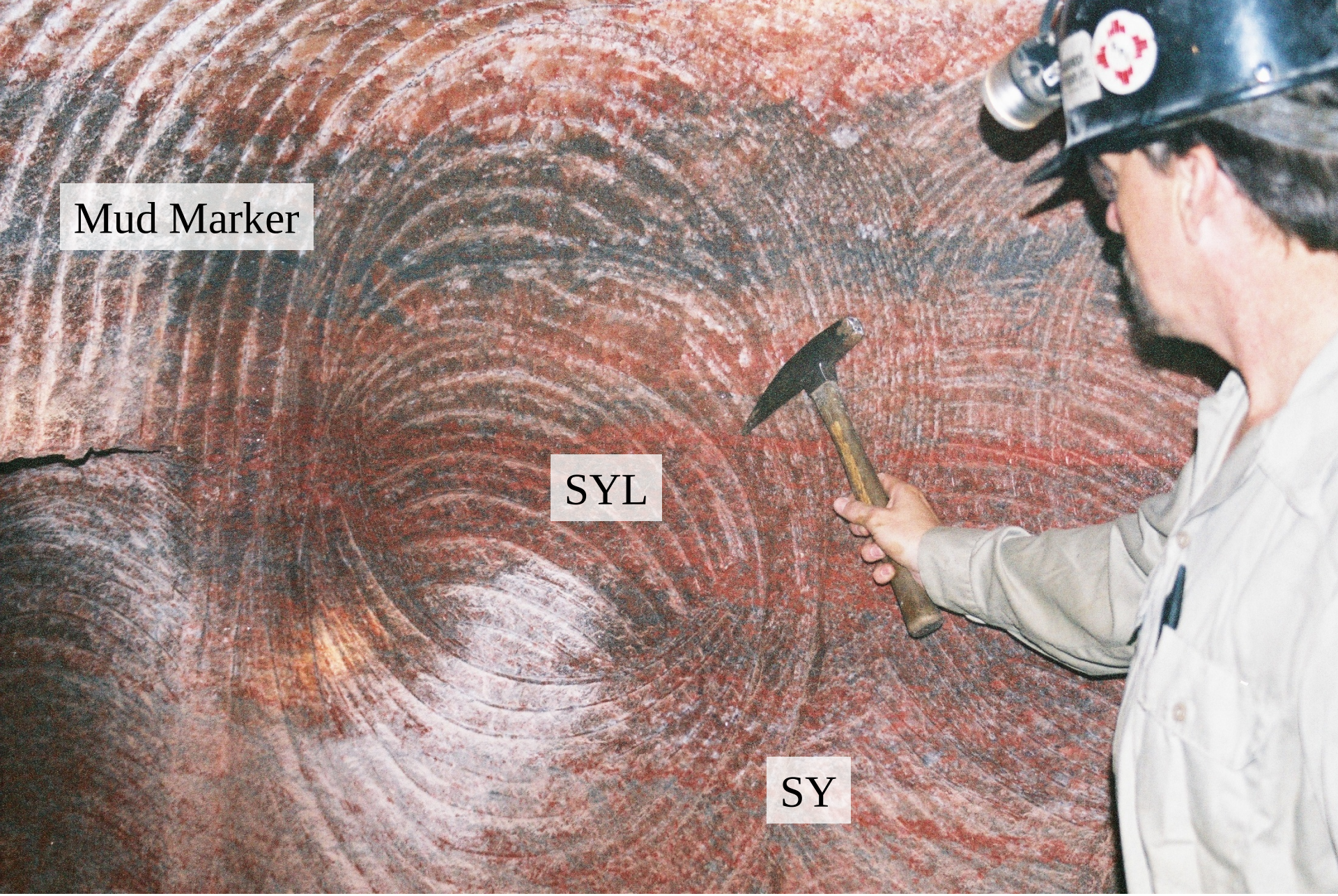

TOYOTA

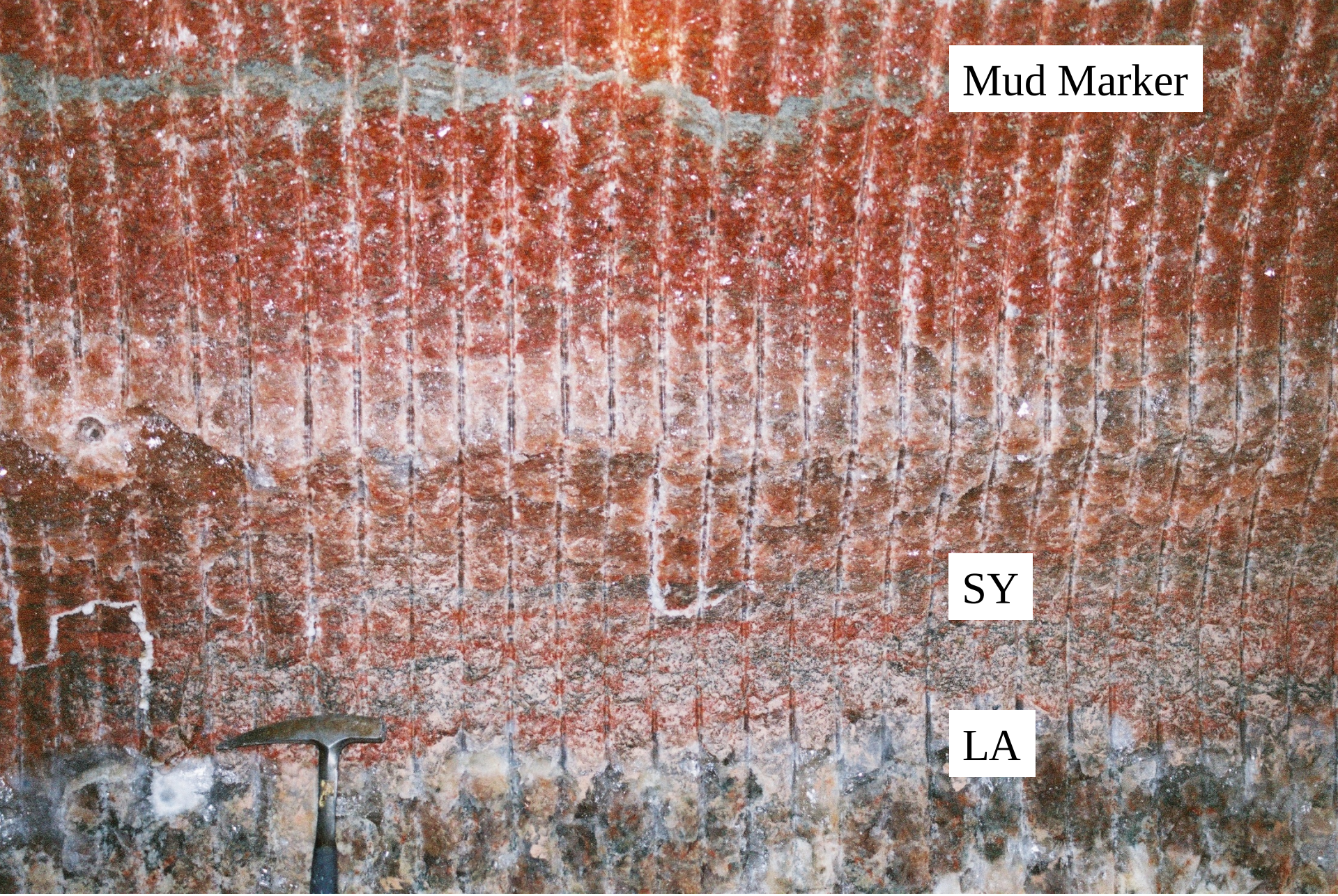
GEOLOGIC PROFILE




Mud Marker


'06 9 6


Mud Marker
SYL
SY


Mud Marker
SY
LA


NO PARKING
ANY TIME
INTREPID
'06 9 6


'06 9 7

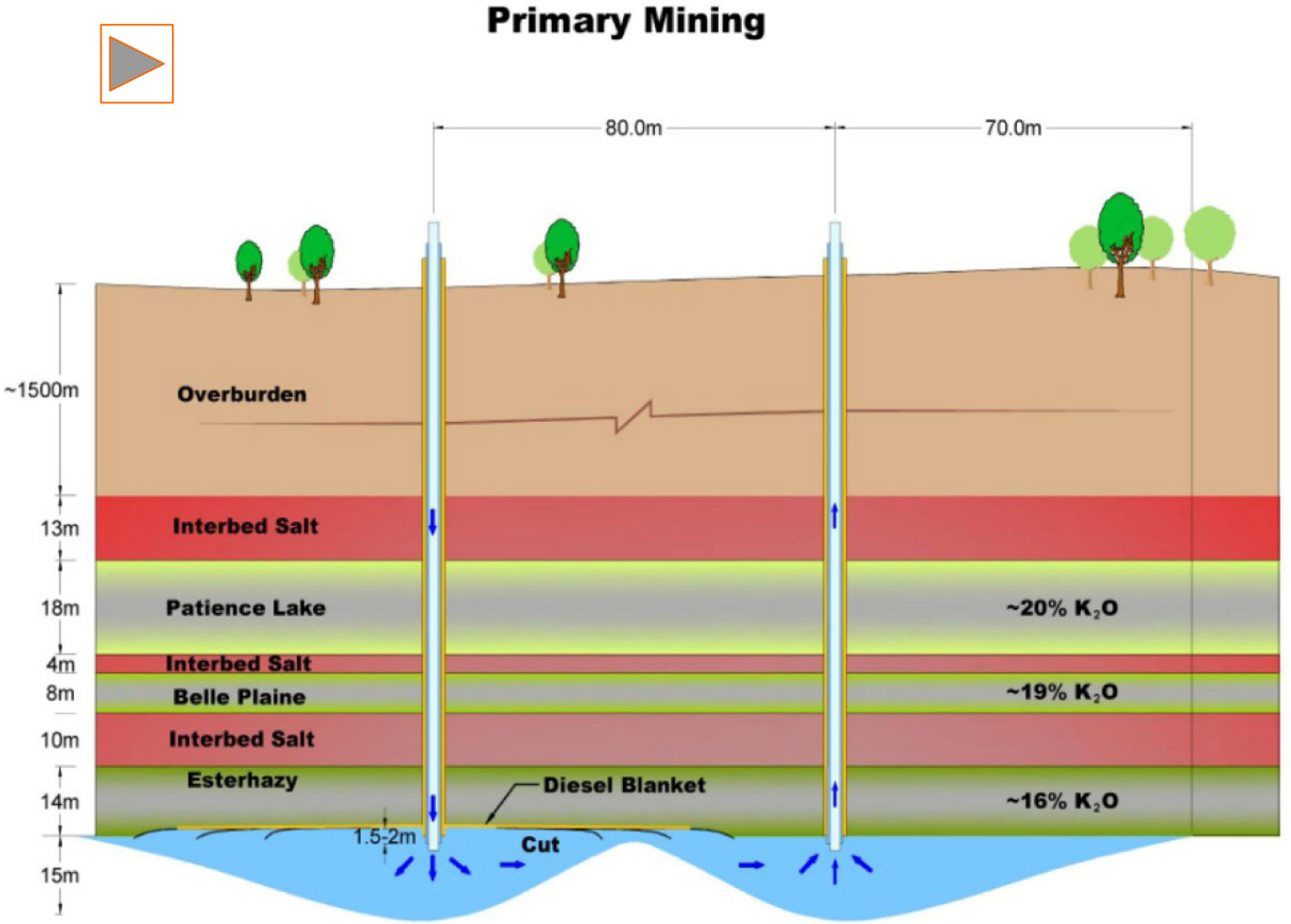
Solution Mining

- Steam or Hot water injected
- Salt saturate inc. Potash recovery
- Single well (concentric casing)
- 150-1500m deep (Barradeel, NL : 2800m)
- One well - 100,000 tonnes

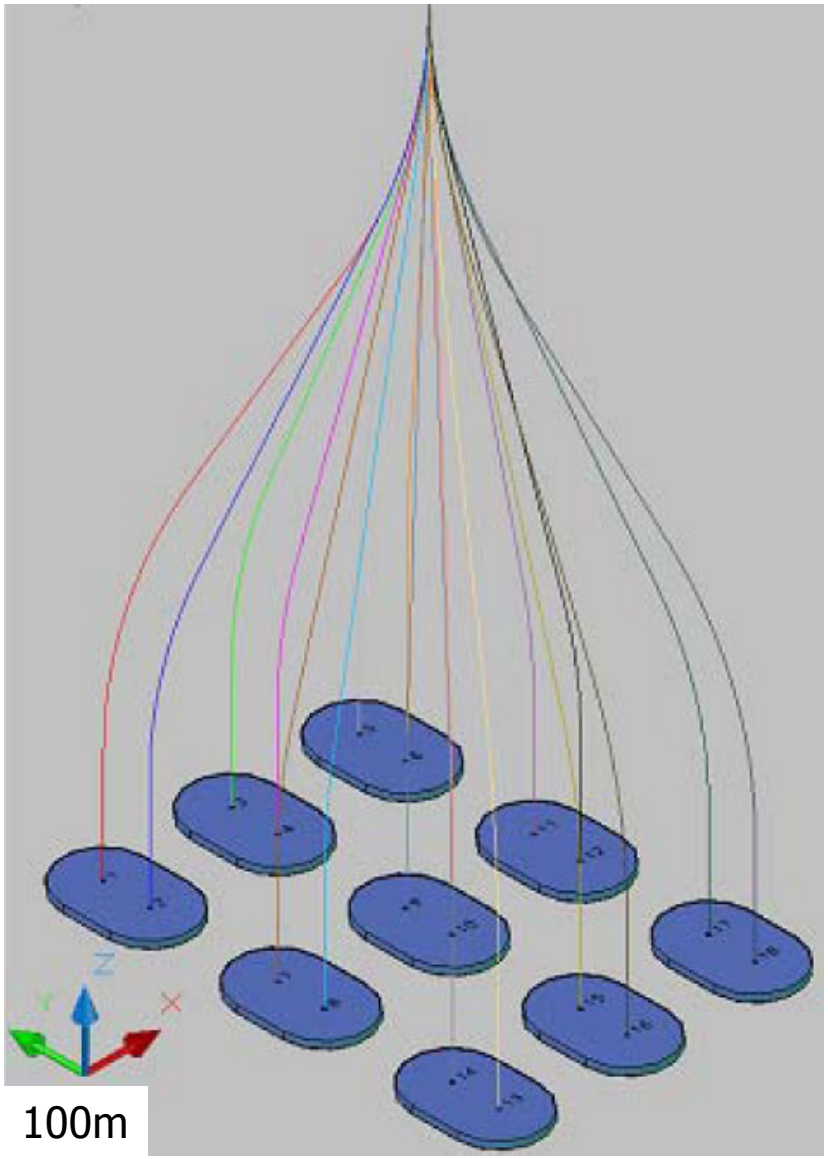
Solution Mining

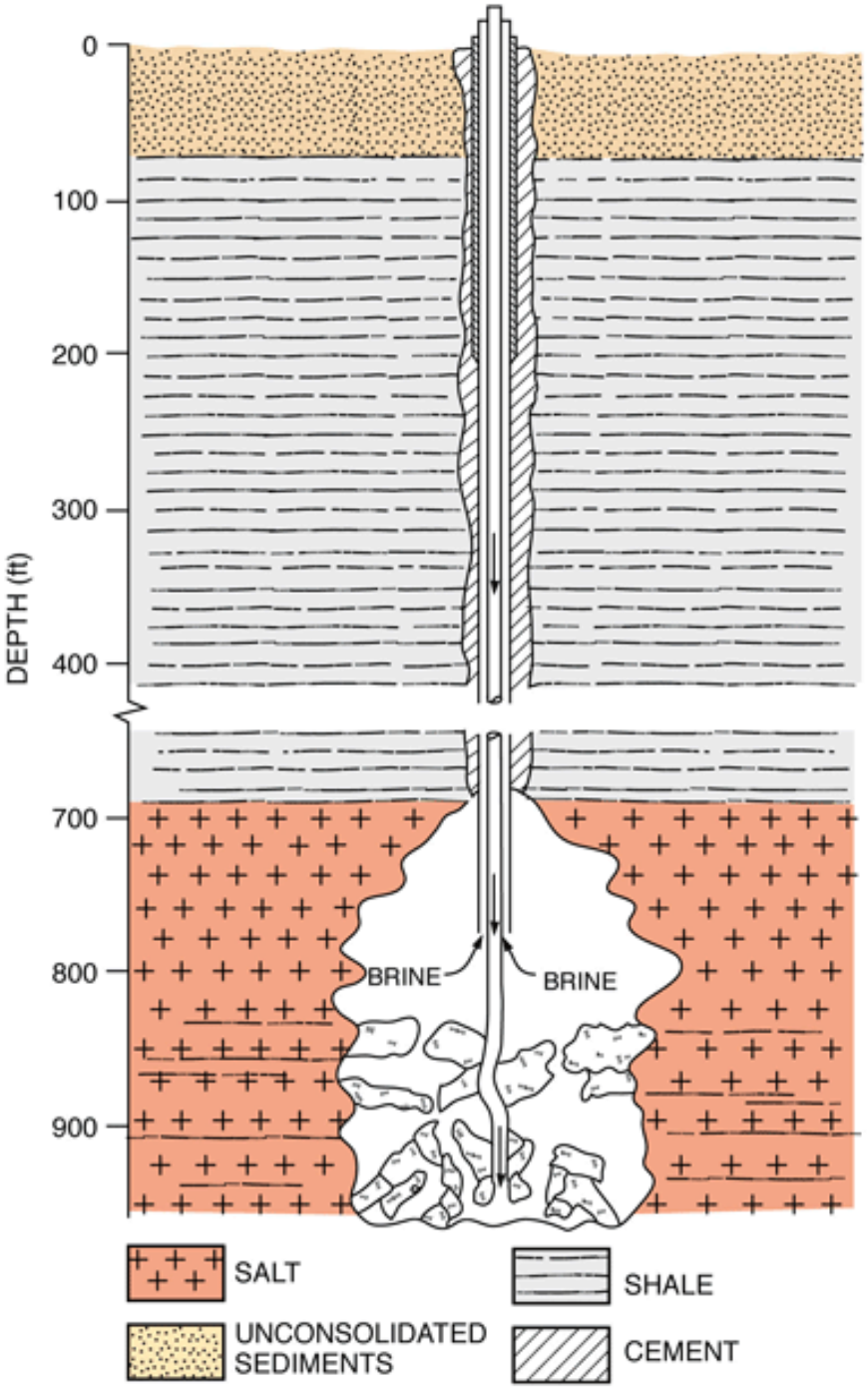
- Major cost
  - Evaporation Ponds
    - plastic liner
  - Drying Kilns - Canada
- Production
  - Sol : 4.5Mt, Belle Plaine, SK (Mosaic)
  - Con : 3.0Mt, Colonsay, SK (Mosaic)

Solution Mining

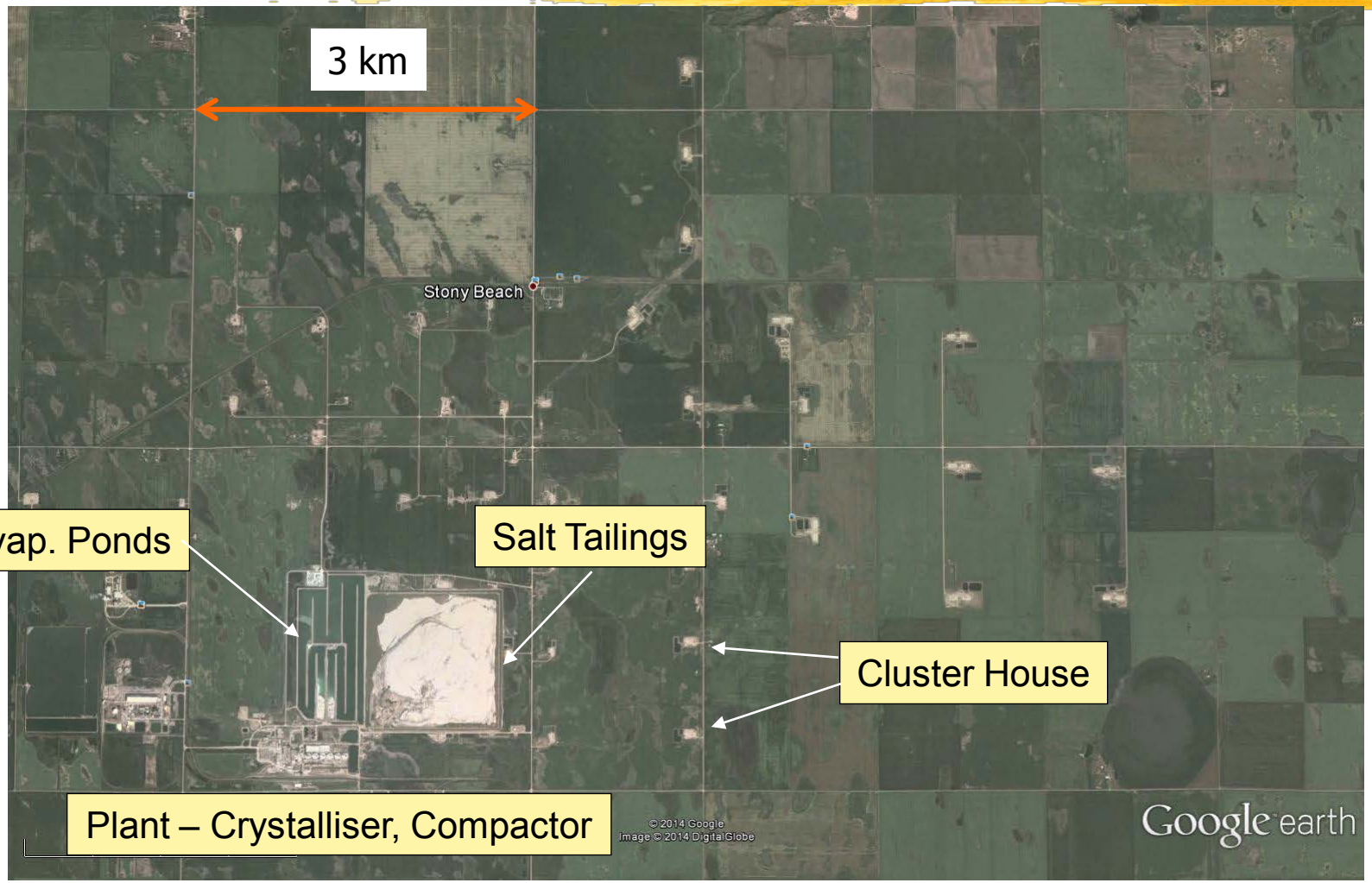


Solution Mining

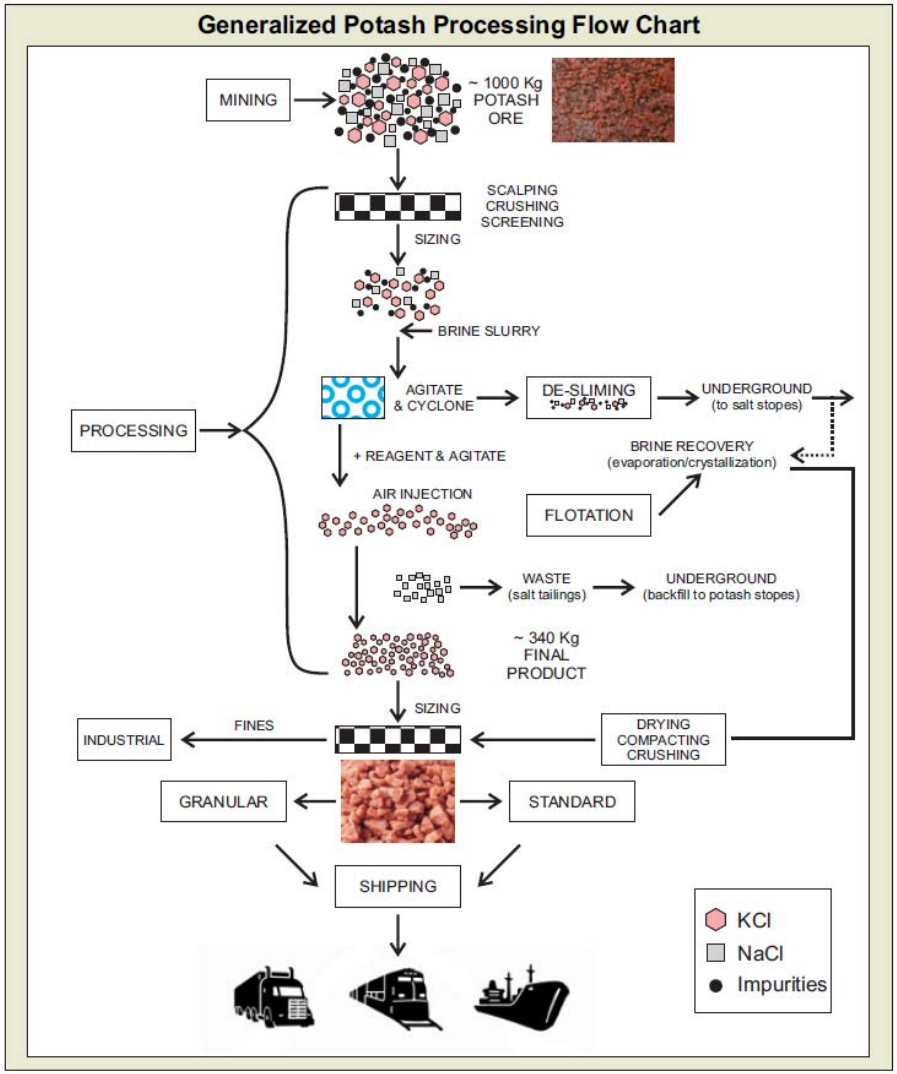




Belle Plain - Mosaic



Potash Milling



Exploration Criteria

- Geological Setting
  - Barred evaporite basin
- Stable tectonic regime
  - Basement blocks
- K (γ) presence indicates fertile (sonic, ρ)
  - Grade +15% K_2O
- Elevated Br (sometimes!)
  - Min. >150ppm Br

Tools – Well Logs

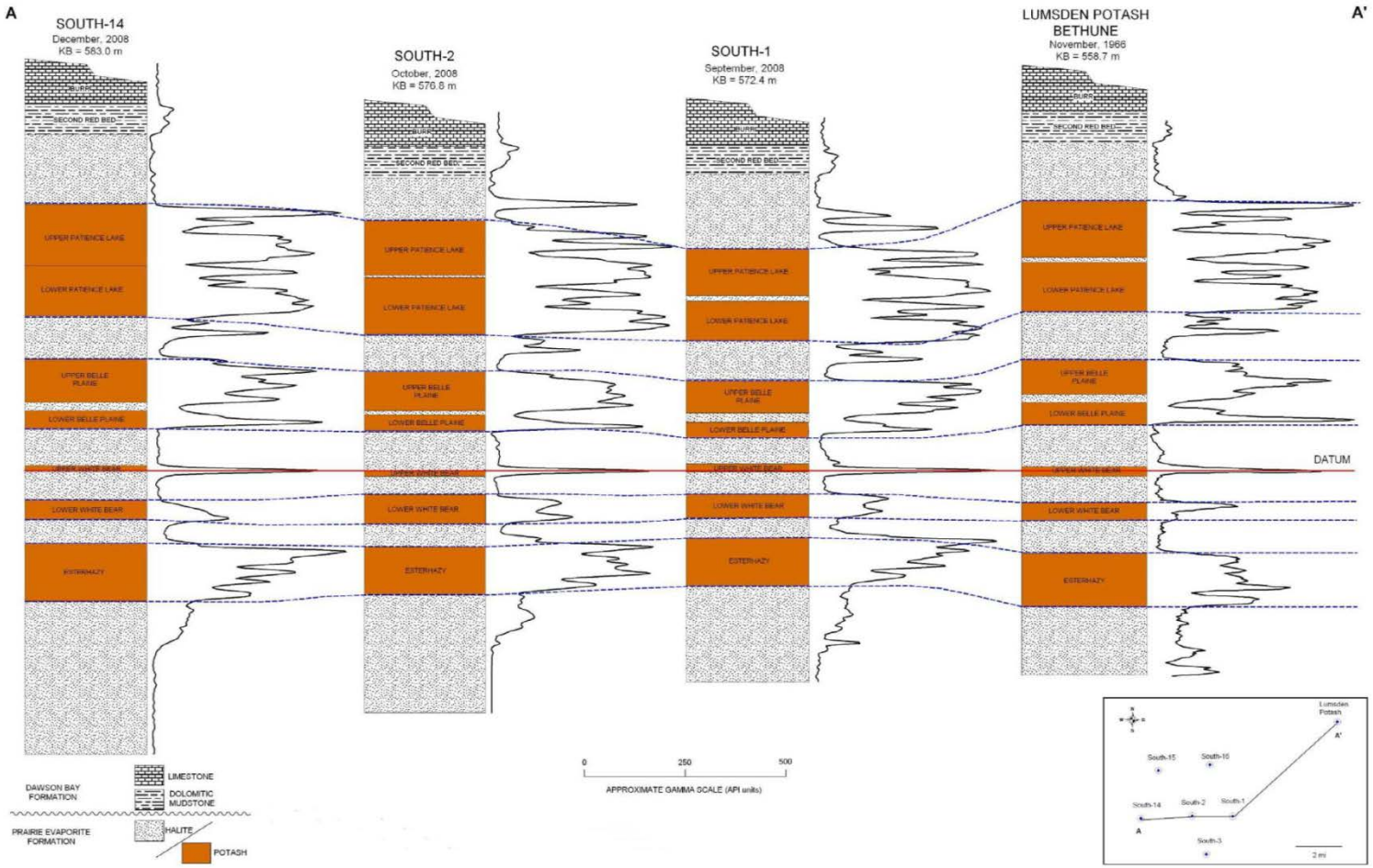
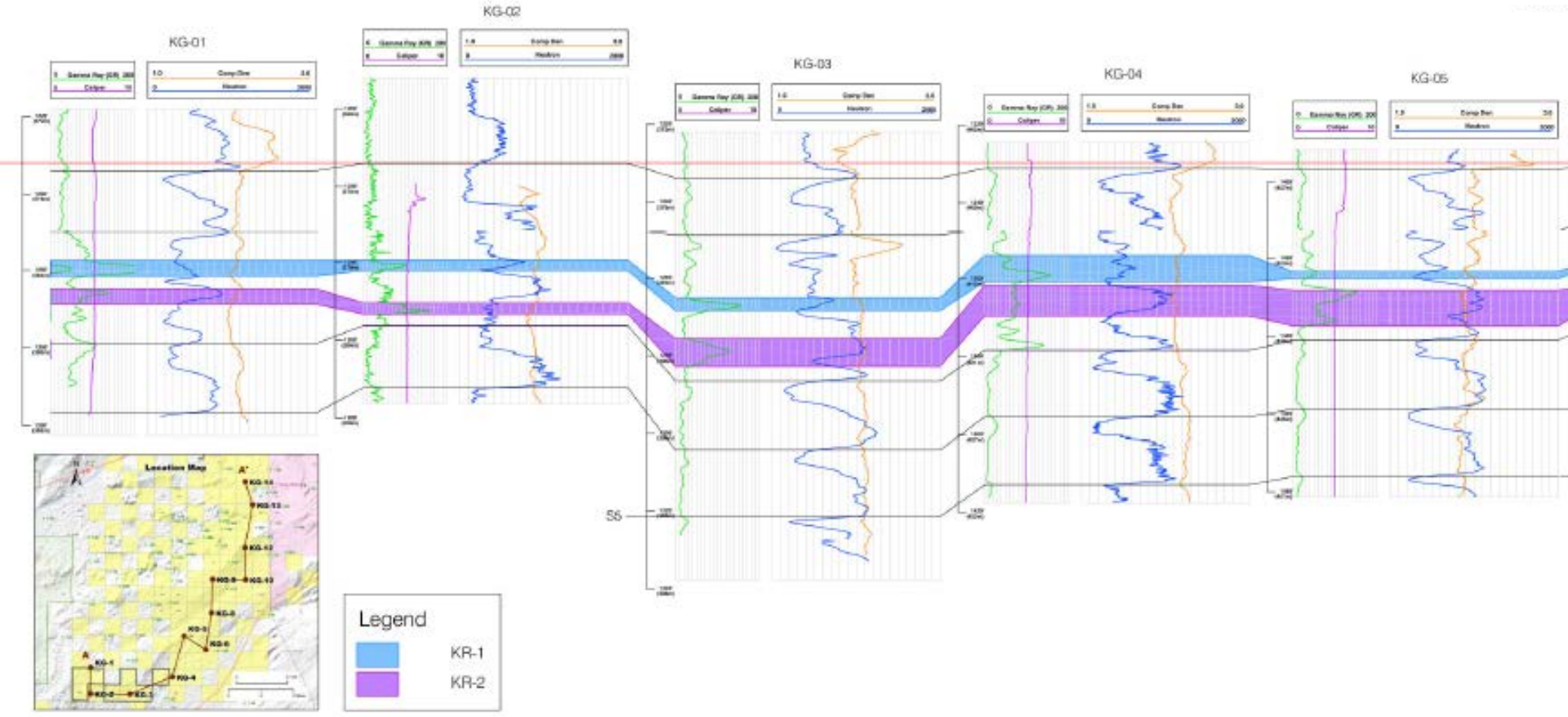


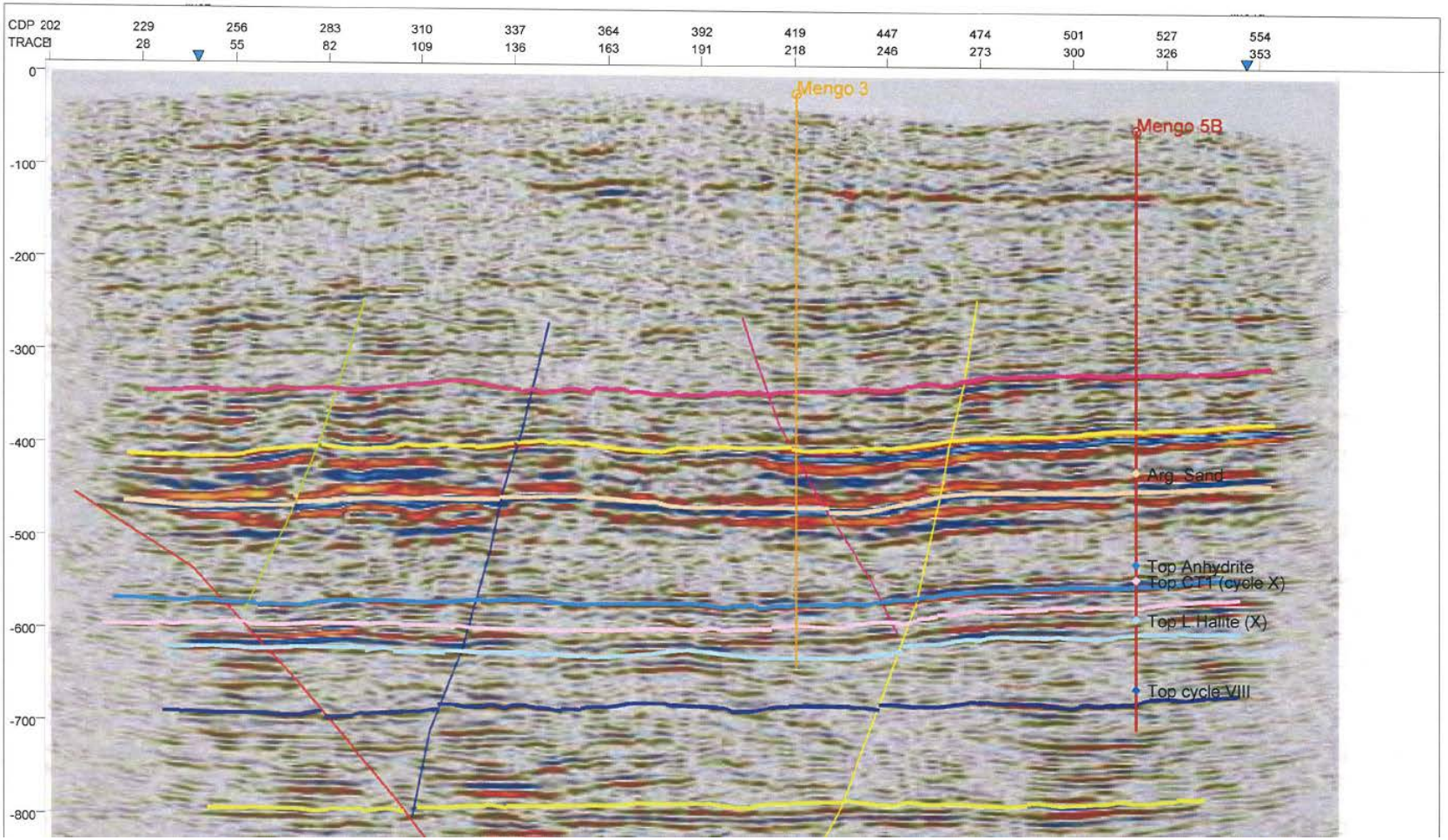
Figure 6. Cross Section A to A′ showing Correlation of Prairie Evaporite Formation Potash-Bearing Members and Gamma Curves for 2008-2009 Drill Holes and Lumsden Historic Hole within KP 289

Tools – Well Logs



American West Potash, 2012

Tools – 2D Seismic



Congo – MagMin, 2007

Tools – 3D Seismic

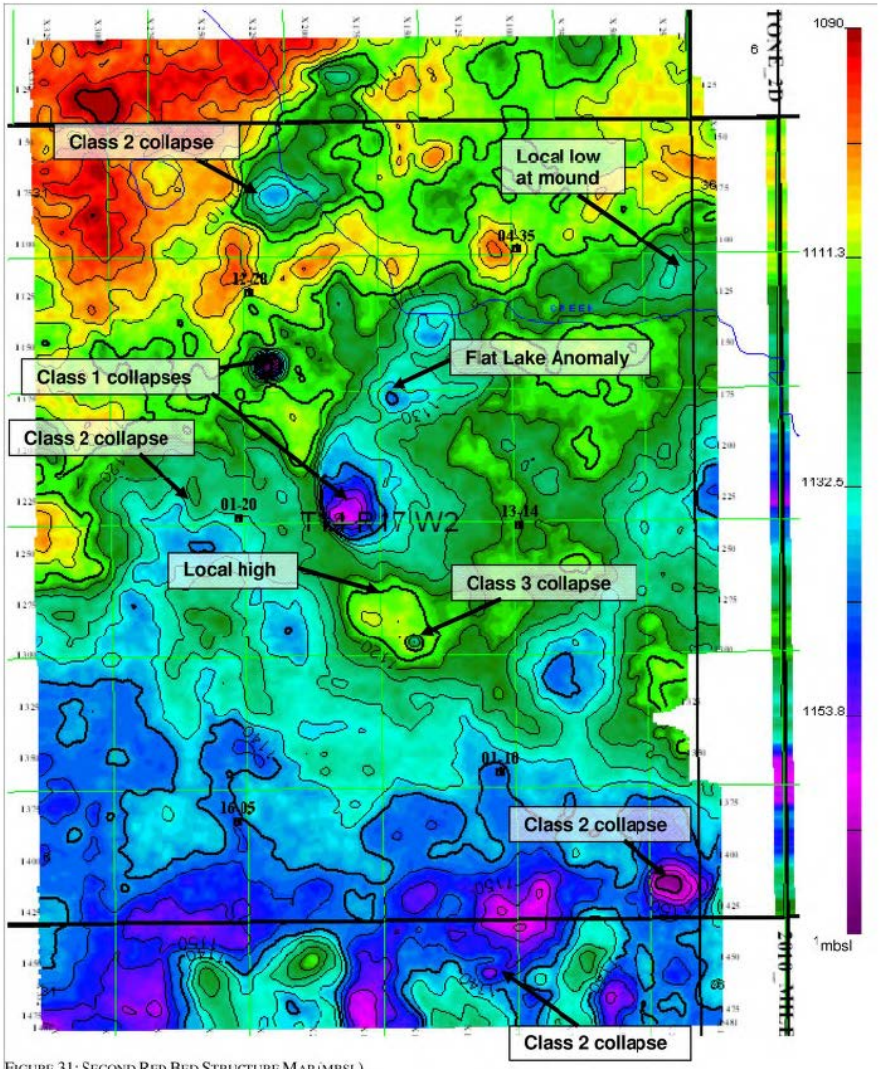
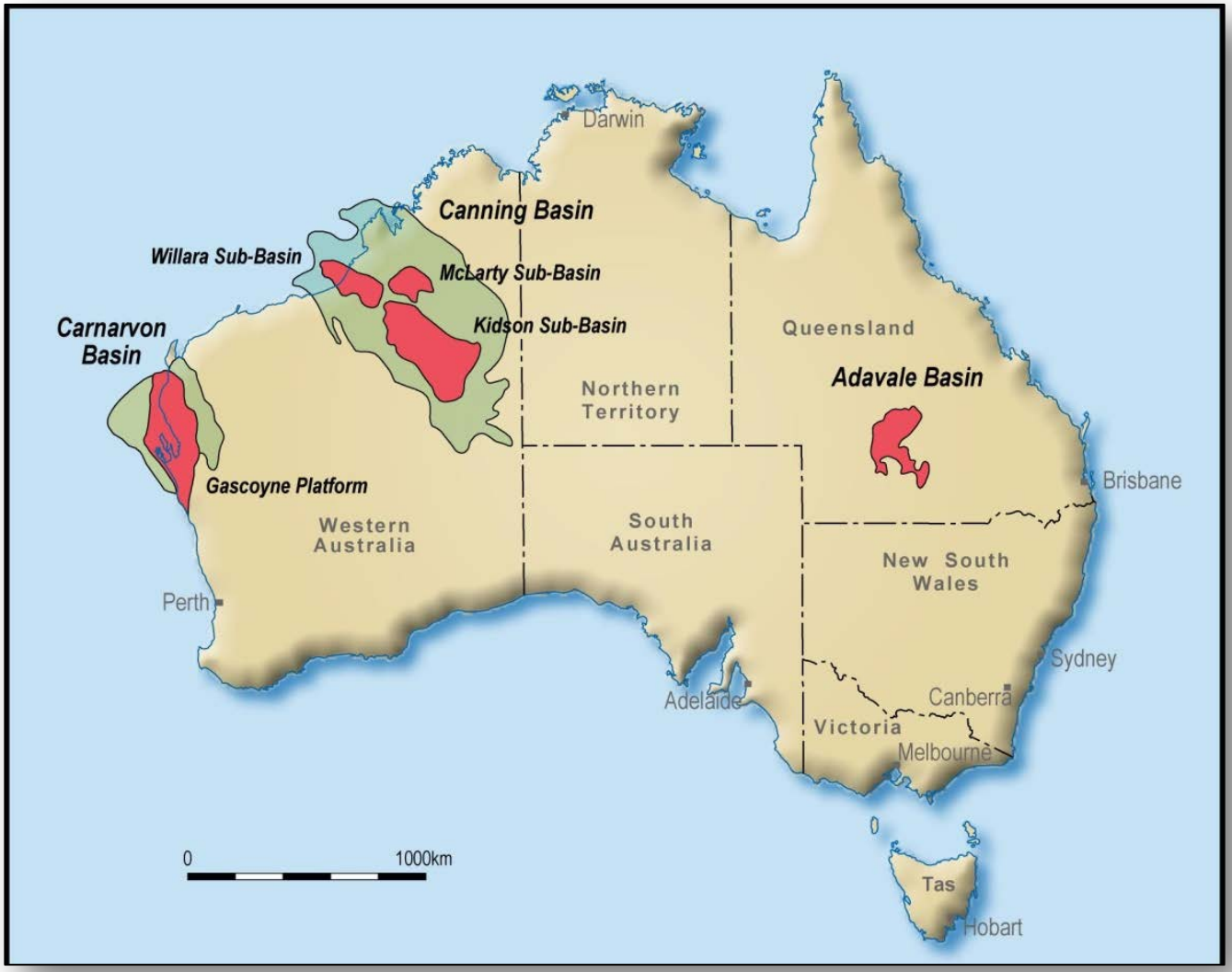


FIGURE 31: SECOND RED BED STRUCTURE MAP (MBSL).

Milestone
Western Potash

Tools

Australia?


Darwin
Canning Basin
Willara Sub-Basin
McLarty Sub-Basin
Kidson Sub-Basin
Carnarvon Basin
Gascoyne Platform
Northern Territory
Queensland
Adavale Basin
Brisbane
Western Australia
South Australia
New South Wales
Perth
Sydney
Adelaide
Canberra
Victoria
Melbourne
0
1000km
Tas
Hobart

Maritimes Potash

Nova Scotia

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global expertise to build your resource base