Tungsten mineralization in Greenland
Preliminary results of a resource assessment workshop

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Greenland Day, Perth 2013
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Why Tungsten?

Important industrial applications:

- Cemented carbides – hard metals
  - tools and equipment for the construction, metalworking, mining, and oil & gas industries
- Tungsten in steel
  - alloying small quantities of tungsten with steel greatly increases its toughness.
  - improving the high temperature properties of steel
- Lamp Industry
  - as filament, or as electrode material
- Electronic and electrical industry
- Chemical applications

Supply risks:
Increasing concentration of production

= Critical Mineral

BGS, 2011 (Source: Roskill, 2010)
Market trends...


Production

Source: USGS, 2013

Total production: 71,120 t WO₃

Reserves 2012

Total reserves: 2,340,200 t WO₃

Production 2012

Source: USGS, 2013

Total production: 71,120 t WO₃
Tungsten – price...

APT = benchmark for tungsten concentrate is ammonium paratungstate (APT), which is the key intermediate product and most commonly traded tungsten material

GFC = global financial crisis

mtu = metric ton units (mtu); 1 mtu of APT contains approximately 7.93kgs of tungsten

Source: Schmidt et al. 2012 (ITIA)
What are we asked as (economic) geologist?

Resources...
• *Where are the deposit(s),*
• *how many*
• *how much,*
• *how do we find it?*

Basically; the starting point... as (economic) geologist...

— *discriminate areas with mineral potential from those that are barren*
Mineral Resource Assessment: tungsten in Greenland

Outline the regional locations, and estimate the probable amounts, of tungsten resources to a depth of one kilometer below the surface in Greenland.

Procedure:
Compile and use all available data and knowledge to facilitate a discussion of possibilities for undiscovered tungsten mineralizing systems/deposits from which estimated numbers of undiscovered deposits can be derived in a quantitative resource estimation.
Two models:
1. Tungsten Skarn Deposits  
   (Cox 1986; SIDEX 2002)

1. Tungsten Veins  
   (Cox & Bagby 1986; SIDEX 2002)

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Fig. 4: Sketch showing the position of tungsten mineralized zone in section.

1. Slate mottled with mica, hornfelsized zone, hornfels zone.
2. Greisenized granite, potassic, sodic-feldspathized granite.
3. Tungsten-bearing quartz vein zone.
The procedure...

- Expert panel – 12 members
  - Tungsten experts from US and Australia
  - Economic and regional geologist, geochemists, geophysicists.
  - Company, Survey and Academic; international
  - Workshop observers

1. Areas with permissive geology are defined (tracts)
2. All data, maps, information, etc. is assessed and discussed – geology, exploration history, etc.
3. Individual bids on the number of undiscovered tungsten deposits in tracts at different confidence levels
4. Consensus bids on undiscovered
5. Estimation of resources [Monte Carlo simulation]

*Mineral Assessment Workshop procedure; slightly modified version of the rules for the ‘3-part undiscovered mineral resource estimation methodology’ developed and used by USGS*
GEUS stream sediment
<0.1 mm grain size fraction
samples with W > 2 ppm

HMCs are obtained using different methods, hence W data are not directly comparable.
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Central East Greenland
• Archean and Proterozoic basement and crystalline complexes
• Mesoproterozoic metasediments – Eleonore Bay Supergroup
• 930 Ma granites
• North Atlantic Caledonies – thrusting
• Caledonian / Devonian granites
• Post Caledonian sedimentary basins
• Palaeogene intrusions
Neoproterozoic - Palaeozoic metasediments
Eleonore Bay Supergroup

14 km of shelf and carbonate platform metasediments

Eleonore Bay Supergroup; Ymer Ø Group, Geologfjord [cliff-face 1 km]
Caledonian / Devonian granites
From Baker, 2005.
Summary:

W anomalies are associated with extensional faulting and
1) late Caledonian leucogranites, where emplaced in lower EBS,
2) Devonian acid magmatism,
3) Palaeogene acid magmatism.

Central East Greenland
Ymer Ø
Tungsten vein structure at south-side of Noa Dal
### Ymer Ø
#### South Margeries Dal

Nordisk Mineselskab, 1984

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<th>Locality</th>
<th>Tonnage</th>
<th>Grade WO₃ %</th>
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Alpefjord Tungsten vein:
Garnet-hbl.-px. skarnoid
• Scheelite, fluorite, sphene, apatite
• 0.1–0.8% W + Be, Sn, Bi
Quartz veins; 5 km²
• Oldest veins carry scheelite
• Younger veins: arsenopyrite, galena, chalcopyrite, pyrrhotite, bismuthinite
• 0.1% W, 0.2% As

Kalkdal Tungsten Skarn:
Biotite granite and granodiorite (434 Ma) skarn in marble within granite contact
• Scheelite in actinolite, diopside and garnet skarn
• Sericitization and scapolite formation
• 500 ppm W (max. 2% W)
## Consensus undiscovered tungsten deposit estimates

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300 km
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Thank you!
Devonian granites

A reddish Devonian granite is seen at the top of the slope. Relief is c.1000 m.

Geochemical Sn, W, Mo, Nb etc. anomalies in the surrounding drainage systems.
Ymer Ø
South Margeries Dal
1979 Outcrops with scheelite located in S. and N. Margeries Dal by Nordisk Mineselskab