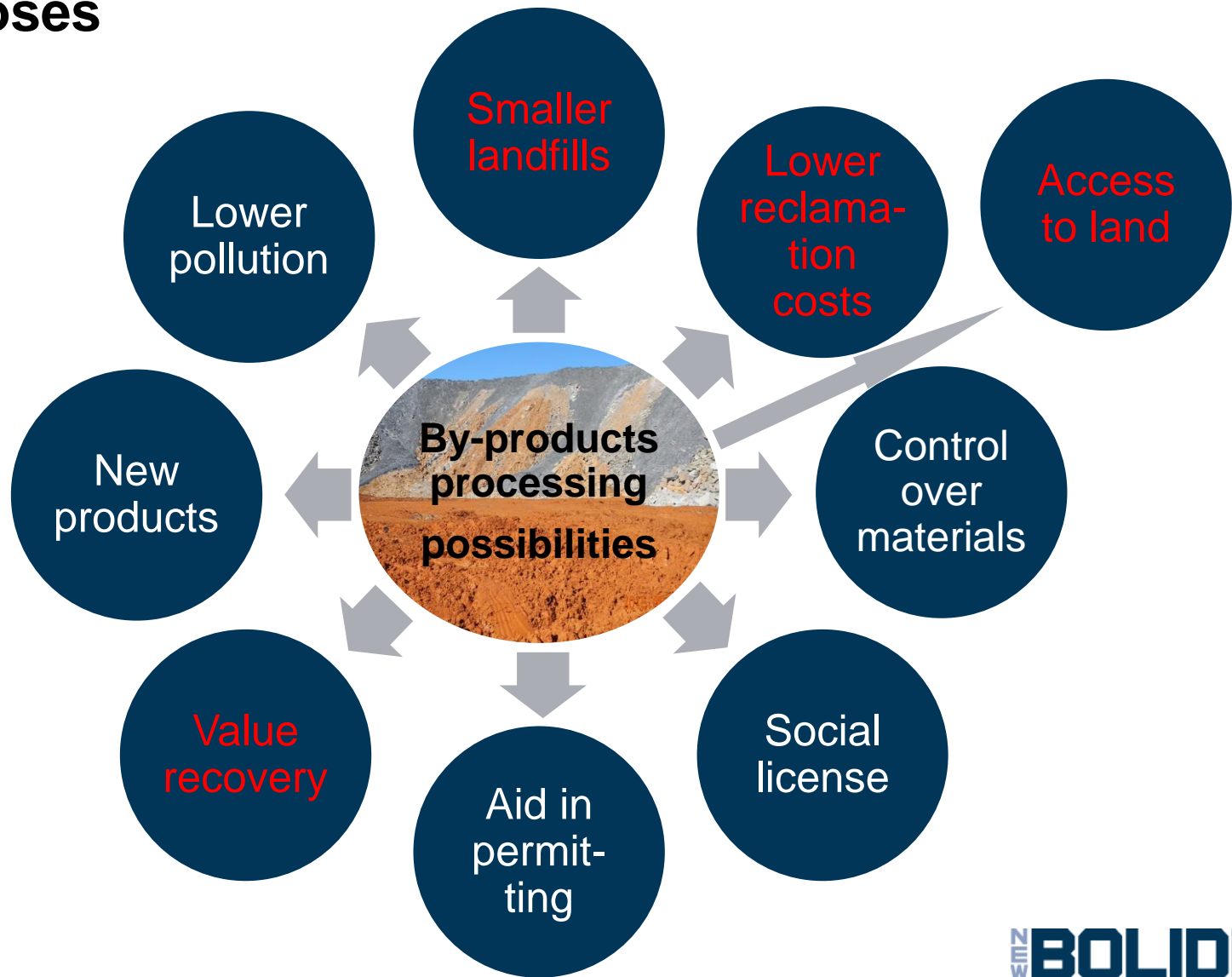


Tailings – opportunities and limitations

Purposes



Utilize values in a deposit

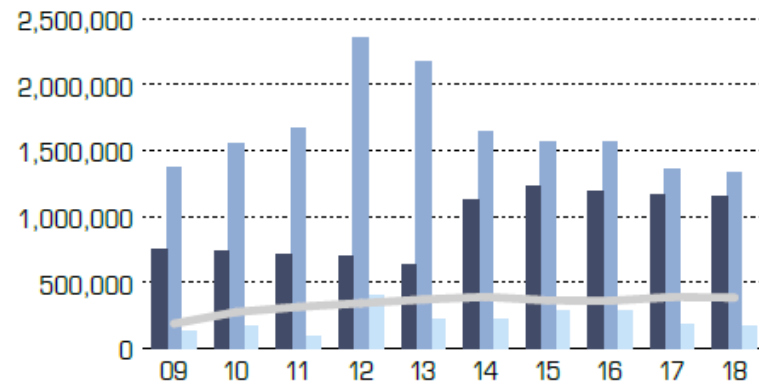
The Aitik example

Production plans

Ore 45 Mton/year
Cu conc. ~350 kt/year
Tailing 45 Mton/year
Waste rock ~45 Mton/year

Reserves in kton 2018

Aitik



Small changes in Mineral Reserves due to changes in the open pit design.

Utilize values in a deposit

The Aitik example

Industrial Mineral		Grade	Variation
Quartz	SiO_2	30	20 - 40
Plagioclase	$(\text{Ca,Na})\text{Al}_2\text{Si}_2\text{O}_8$	15	15 - 50
Microcline	KAlSi_3O_8	20	15 - 50
Biotite	$\text{K}(\text{Mg,Fe})_3(\text{OH,F})_2$	15	5 - 35
Muscovite	$(\text{Al,Fe})\text{Si}_3\text{O}_{10}$	8	2 - 25
	$\text{KAl}_2(\text{OH,F})_2$		
Barite	BaSO_4	0,2	0 - 0,5
Apatite	$\text{Ca}_5(\text{PO}_4)_3$	0,5	0,3 - 0,7
Garnet	$(\text{Mg,Fe,Mn,Ca})_3$	2	0 - 5
	$(\text{Al,Fe})_2\text{Si}_2\text{O}_{12}$		
Turmaline	$(\text{Ca,Na,K})_6$	1,5	0 - 3
	$(\text{Al,Mg,Fe})_6$		
Magnetite+Ilmenite	$\text{Si}_6\text{B}_3\text{H}_x\text{O}_3$	1,5	
	$\text{Fe}_3\text{O}_4 + \text{TiO}_2 \cdot x\text{FeO}$		

Utilize values in a deposit

The Aitik example

- 1964 - Magnetite (Fe_3O_4) production was studied before mining started at Aitik.
- 1968 – Copper concentrate production started
- 1969 - 1970 A small production of pyrite (FeS_2) concentrate was tested but the economy was not good. Several attempts have been done later but the value is too low and the transportation cost too high.
- 1971 Recovery of Ti, V, P, Mo, Co and Ni was studied.
- 1974 Recovery of Apatite, Barite, Muscovite, Biotite and Garnate was studied.

- 1974, 2011 Recovery of REE from the bulk tailing (Rare Earth Elements)
- 1976 Several industrial minerals were studied as possible by-products
- 1978 Muscovite-biotite production was looked upon as replacement for asbests.
- 1979 More tests on recovery of industrial minerals
- 1980 – 83 Pilot plant production (~500 t/y) of muscovite and biotite concentrates. Other industrial minerals tested in lab scale.
- 1981 – 2012 Recovery of Scheelite (CaWO_4)
- 1981 – 83 Mo recovery from Cu concentrate studied in lab tests

1984 – 86 Studies of Au recovery from HS product (High Sulphur)

1992, 1993, 1998 More tests on Au recovery from the HS product

2007 – 2011 Pilot plant studies of Mo recovery from the copper concentrate.

2011 – 2015 Studies of magnetite (Fe_3O_4) recovery from the bulk tailing in lab and pilot scale.

Other recent examples

An on-going project to recover cobalt and other metals from the high sulphur deposit at the Luikonlahti mill in Finland

Recovery of vanadium from the LD-slag at SSAB

Tailings for construction uses were studied in the 70-ties. The idéa is "on the table" again and a new study might start soon again.

Iron sand as substitute for cement have recently shown very promising results and addition of tailings with high Ca content can give even better results.

Minimize waste from an open pit

Mining:

- The steeper the sides of the open pit the less waste needs to be removed.
- Keep the sulphur free waste separate from sulphur containing waste as much as possible.
- Deposit as much as possible underground

Total operation:

With low cost for the operation and good recovery of valuables will it be possible to upgrade most of the ore and minimize stockpiling of low grade waste rock with possible AMD properties.

Production plans

until ~2045

Ore 45 Mton/year

Cu conc. ~350 kt/year

Tailing 45 Mton/year

Waste

rock ~45 Mton/year

Waste rock is regarded "harmless" if

it contains:

<0,1% sulphur

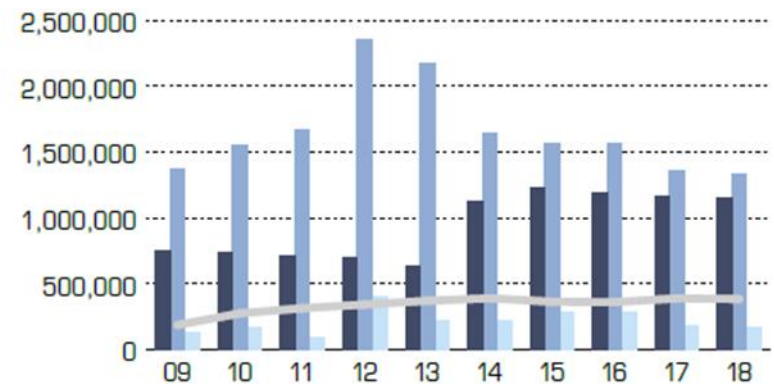
<0,03% Cu

NP/AP>3



Reserves in kton 2018

Aitik



Small changes in Mineral Reserves due to changes in the open pit design.

BOLIDEN