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Sergei Sabanov, PhD ssabanov@srk.co.uk

Oil Shale Beneficiation Considerations

Sergei Sabanov, *PhD*

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srk consulting

Contents

Sergei Sabanov, PhD ssabanov@srk.co.uk

Key facts about SRK Consulting

Sergei Sabanov, PhD ssabanov@srk.co.uk

SRK Services

- Multi Disciplinary Services Exploration
- Mining Geology & Resources Estimation
- Mineral Reserves & Ore Reserves Reporting
- Mining Engineering
- Geotechnical Engineering
- Mineral & Metallurgy Processing
- Tailings & Waste Management
- Geochemistry
- Environmental & Social
- Mining Economic

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Sergei Sabanov, PhD ssabanov@srk.co.uk

SRK Oil Shale projects

- Estonia- Resource and Reserves
- Jordan – Managing of Prefeasibility Study
- Brazil - Benchmarking the Mining Operation
- Byelorussia –Mineral Expert Report

Sergei Sabanov, PhD ssabanov@srk.co.uk

SRK Exploration Services

SRK ES is currently involved in directing and designing Oil Shale exploration in North America and the Middle East and has qualified professionals with extensive experience in working with Oil Shale and other stratiform deposits.

Specific oil shale experience:

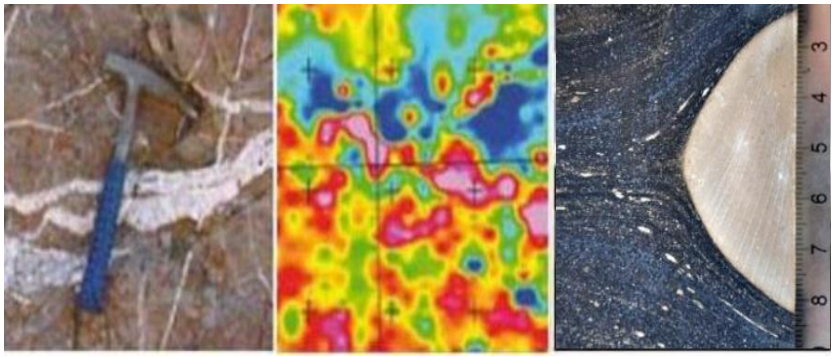
- Independent project reviews and fatal flaw analyses
- Exploration design and scheduling
- Exploration field and logistics management
- Exploration programme implementation and geological supervision
- Oil shale assay analysis and quality review
- Design and implementation of international best practices
- Technical drilling quality reviews and advice
- Oil shale exploration project management
- Data collection, compilation and database construction

SRK ES has the added advantage of being able to draw on the wider SRK Group's experience and therefore take projects beyond the exploration phases through to resource modelling and ultimately towards feasibility and production studies.

Sergei Sabanov, PhD ssabanov@srk.co.uk

SRK Exploration Services in Jordan

- Reviewed, amended and redesigned exploration programmes
- Designed sampling procedures and flow paths along with parallel quality control protocols
- Designed, processed and interpreted geophysical data
- Acted as the JORC Qualified Person during exploration programmes
- Undertaken targeted structural mapping exercises
- Reviewed sequence stratigraphy studies along with oil shale weathering studies
- Reviewed annual and programme end reporting
- Complied and audited exploration data/databases



Sergei Sabanov, PhD ssabanov@srk.co.uk

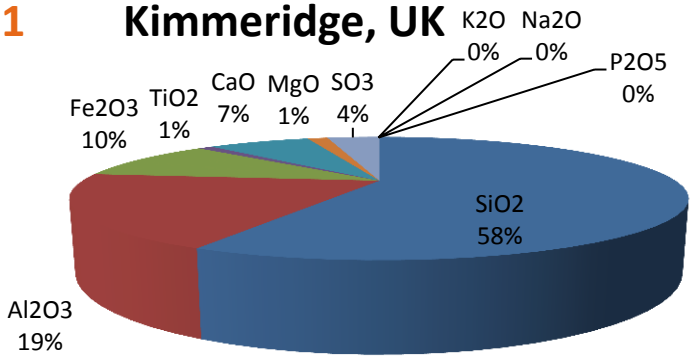
Oil shale deposits

1. Chemical composition of the mineral part
2. Elemental composition of kerogen

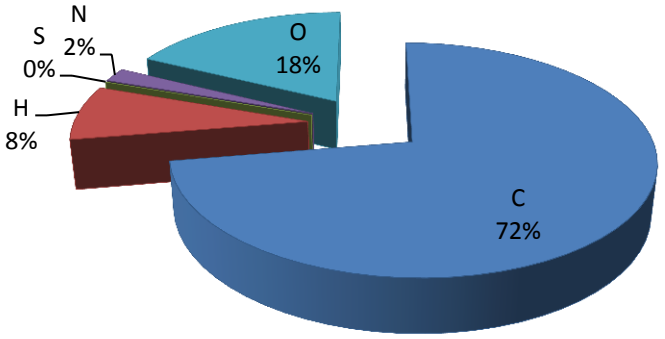
Oil shale products:

- oil – 25.5%
- Semicoke- 60.2%
- Gases- 10.7%
- Pyrolitic water – 3.6%

1 **Kimmeridge, UK**



2 **Kimmeridge , UK**



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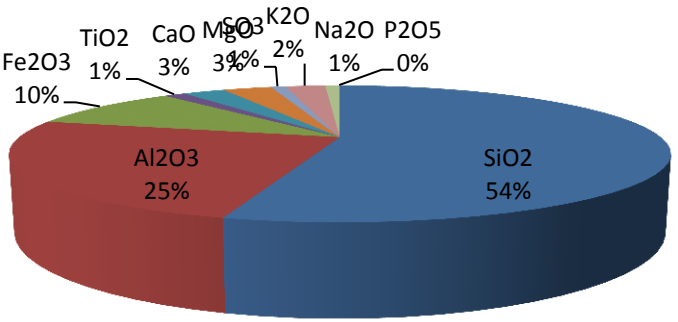
Oil shale deposits

1. Chemical composition of the mineral part
2. Elemental composition of kerogen

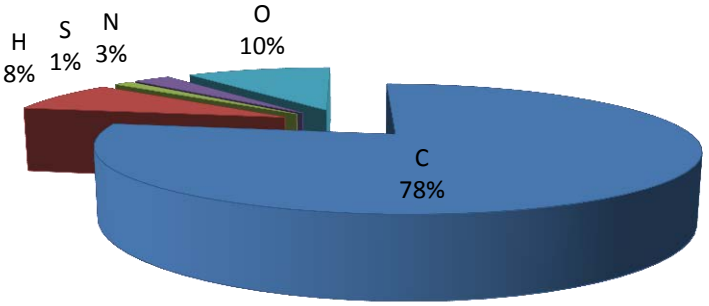
Oil shale products:

- oil – 8.2%
- Semicoke- 86.6%;
- Gases- 3%
- Pyrolitic water – 2.2%

1 **Westwood, Scotland (UK)**



2 **Westwood, Scotland (UK)**



Sergei Sabanov, PhD ssabanov@srk.co.uk

Oil shale deposits

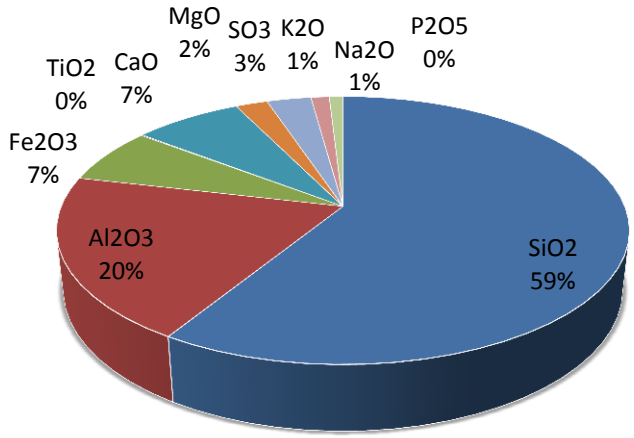
1. Chemical composition of the mineral part of boltysheski oil shale deposit
2. Elemental composition of kerogen

Oil shale products:

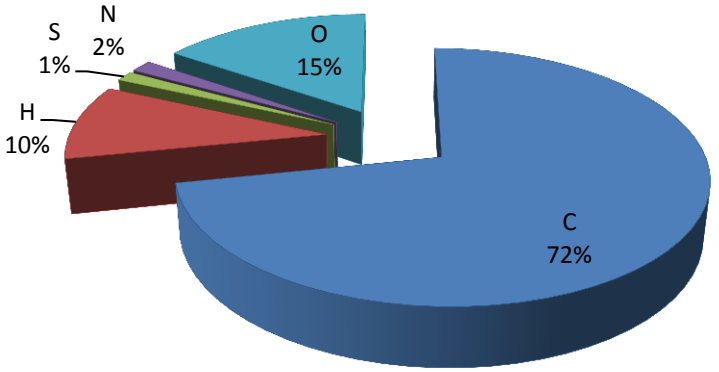
- oil – 17%
- Semicoke- 73%;
- Gases- 6%;
- Pyrolitic water – 4%

Organic compound is typical sapropelite, which in some cases contains humus.

1 **Boltysh (Ukraine)**



2 **Boltysh (Ukraine)**



in oil shale	%
Ni	0.030
Co	0.003
Cr	0.030
Zr	0.030
Cu	0.030
Ge	0.030
V	0.030

in ash	%
Ni	0.01-0.03
Co	0.001-0.004
Cr	0.003-0.03
Zr	0.01-0.03
Pb	0.003
Sr	0.03-0.1
V	0.001-0.03
Ba	0.03-0.3

Sergei Sabanov, PhD ssabanov@srk.co.uk

Oil shale beneficiation

Grade distribution by blast breakage:

$$Gx = \Delta G \exp(-kx) + G_{ROM}$$

- G_x – grade of the size 0–x (mm)
- ΔG_x – effect of selective crushing
- k – parameter of distribution
- x – grain size
- G_{ROM} – grade from ROM.

$$y = A * n + \delta$$

y – screen underflow;

x – grain size, mm;

A - part of fine grains less 1 mm,

n – granularity range;

δ – pieces splitting at transportation

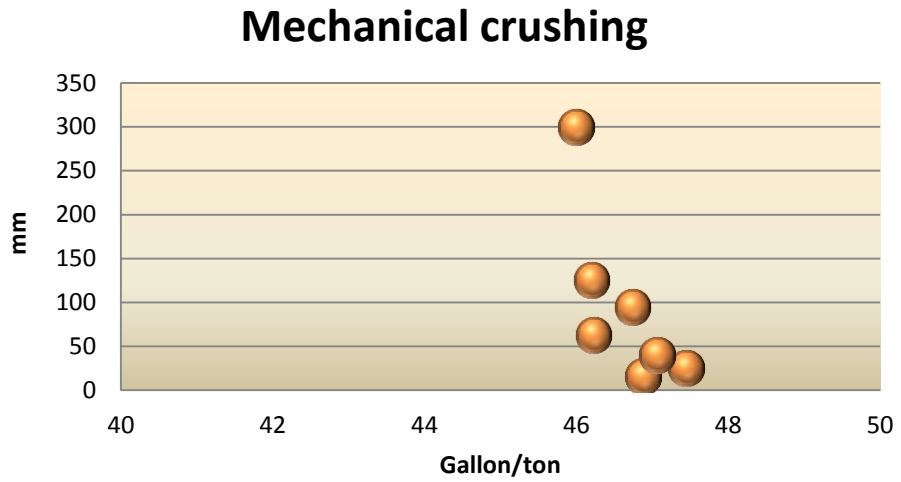
Parameters	Symbol	Mining method		
		Drill&Blast	Mechanical cutting	Ripping
Granularity	*n*	0.5-0.6	0.3-0.5	0.4
Splitting factor	*A*	0.03-0.06	0.06-0.02	0.1-0.2
Fines factor	*δ*	0.05-0.15		
Distribution factor	*k*	0.006-0.05	0	-
Selective crushing factor	*ΔQ*	3.0-5.8	0	-

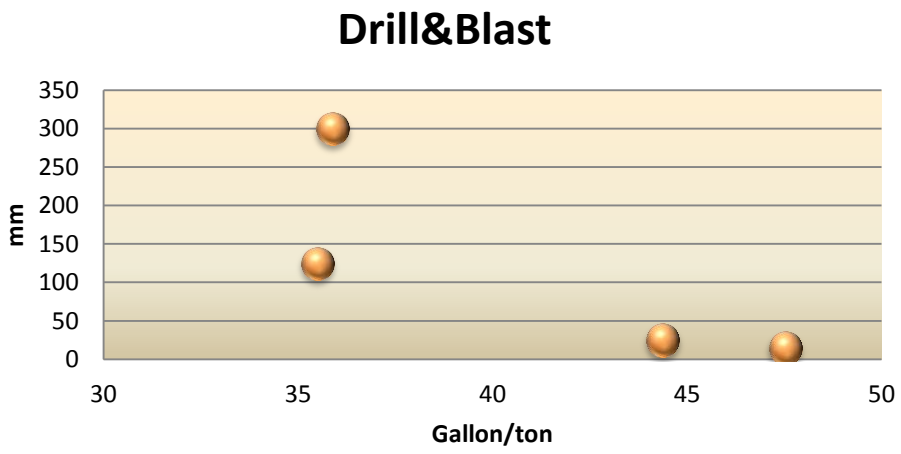
Sergei Sabanov, PhD ssabanov@srk.co.uk

Oil shale grade distribution

Average grade in oil shale layer with concretion:

$G_{AV} = (G_{os} * m_{os} + G_c * m_c) / m_{AV}$



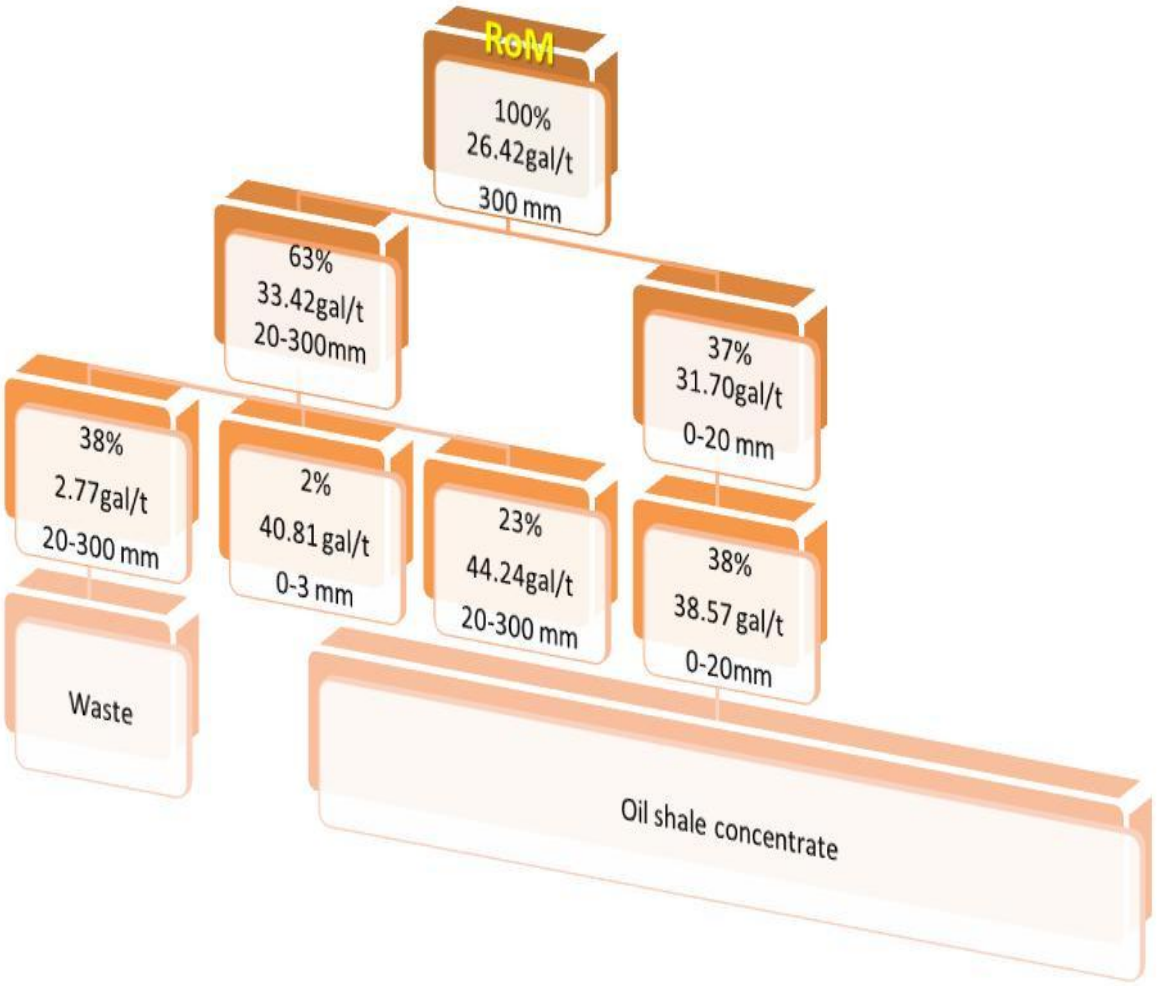


Sergei Sabanov, PhD ssabanov@srk.co.uk

Oil Shale beneficiation flow sheet diagram

Flow diagram processes:

1. Dry screening
2. Coarse concentration
3. Wet screening
4. Fine concentration
5. Dewatering
6. Final product blending



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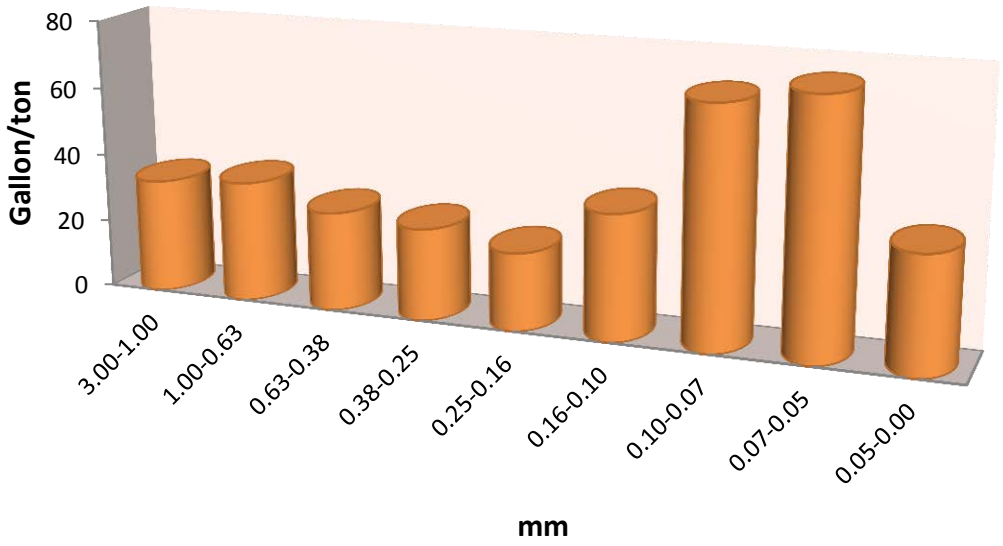
Fines oil shale grade distribution

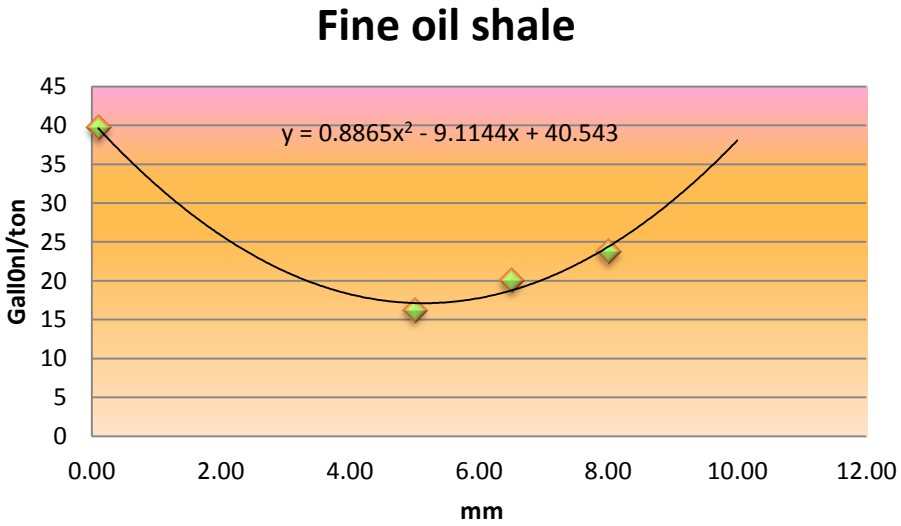
- Fine particles of oil shale 0.1-0.05 mm have higher grade and don not contain sand and clay inclusions



Sergei Sabanov, PhD ssabanov@srk.co.uk

Wet screen separation

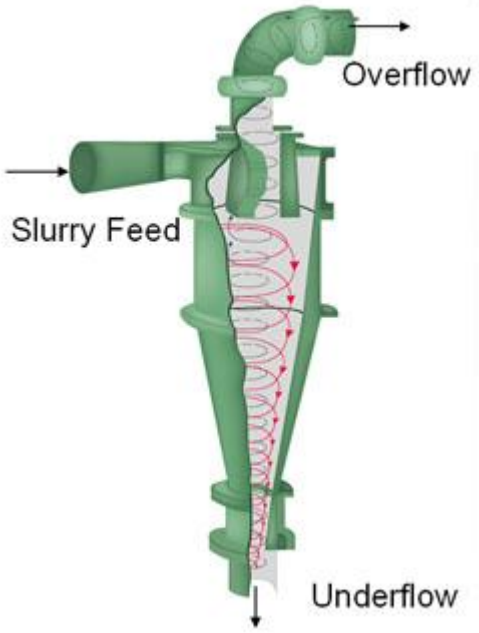
- Wet screen separation process includes water which then contain 2-3% of fine oil shale
- Fine oil shale 0-8mm can be separated by radial thickener or hydrocilones

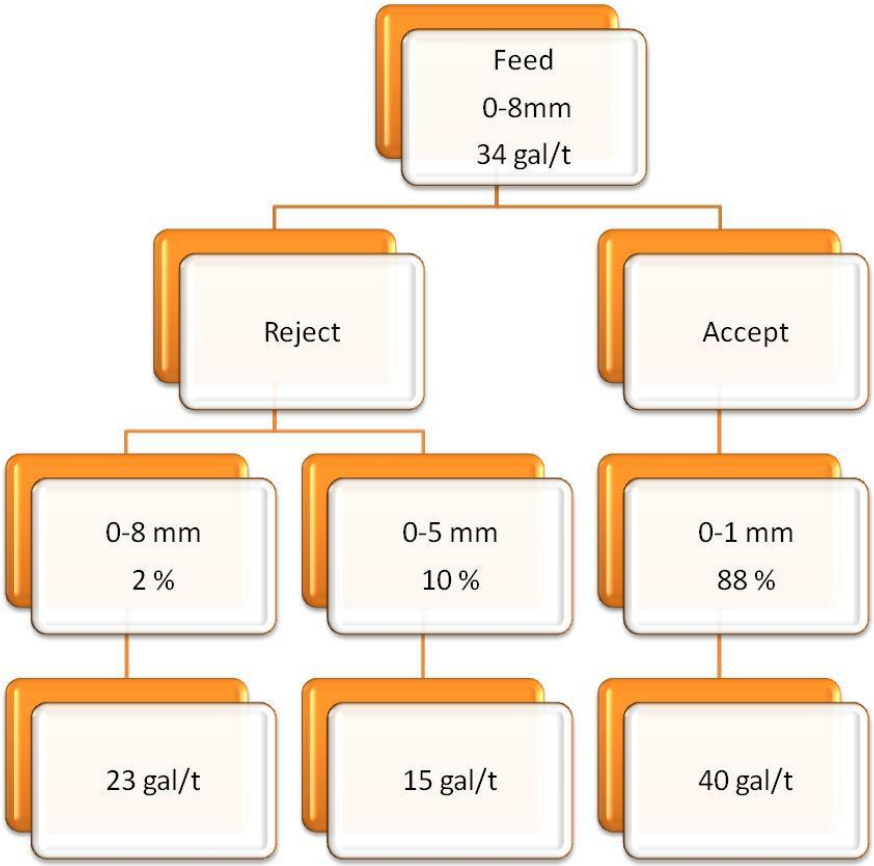


Sergei Sabanov, PhD ssabanov@srk.co.uk

Hydrocyiclone separation

- Hydrocyclones have low efficiency in separation of fine oil shale slurry substances from waste material and need additional dewatering installations to dry oil shale

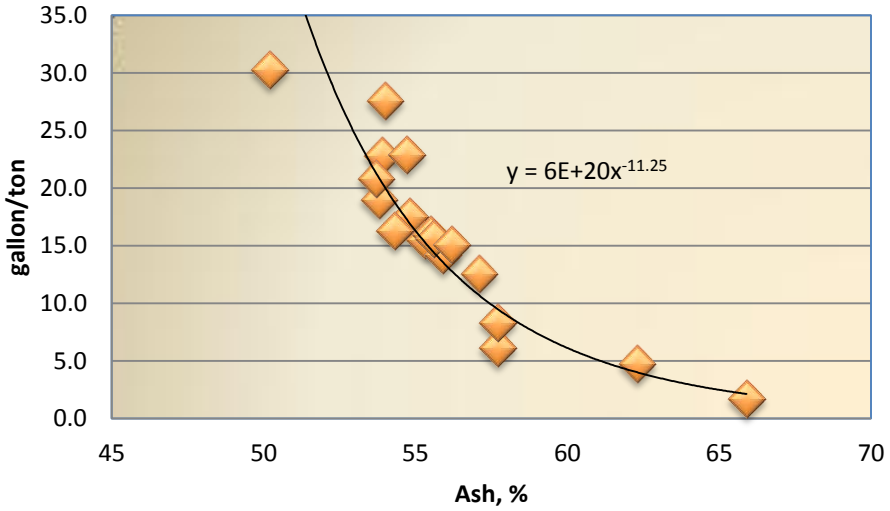




Sergei Sabanov, PhD ssabanov@srk.co.uk

Fine oil shale grade and ash content distribution

- Fine particles of oil shale 0-8mm have ash content 50-67%
- Aliminosilicate-Carbonate (CaO+MgO >10%)

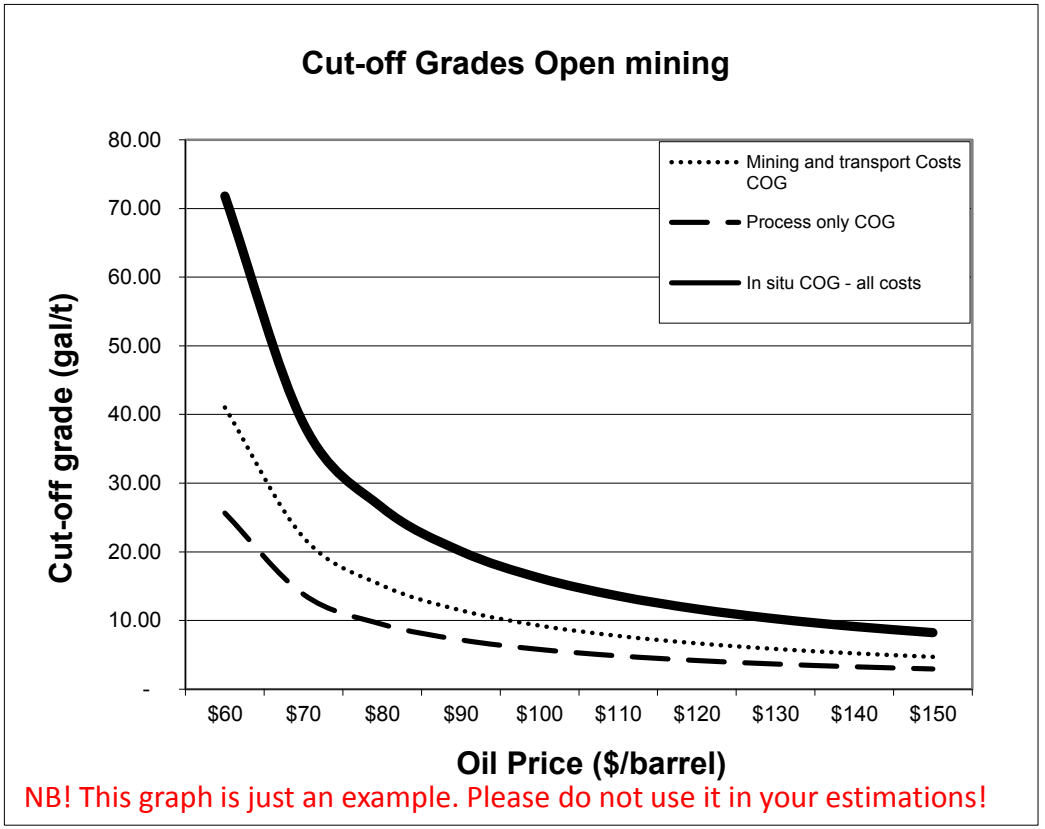


Sergei Sabanov, PhD ssabanov@srk.co.uk

Cut-off Grades

- Stripping ratio – 4:1($t_{ore}/t_{oil\ shale}$)
- Productive oil shale seam thickness 4-12m
- Stope recovery-95%
- Dilution-5%

- Must define material which has potential for eventual economic extraction:
  - optimistic revenue parameters
  - realistic technical parameters
  - benchmarked costs
- Must calculate and use an appropriate cut-off grade (COG) to the envisaged mining method
- Material above the COG must form spatially contiguous volumes that would/could form mining targets



NB! This graph is just an example. Please do not use it in your estimations!

Sergei Sabanov, PhD ssabanov@srk.co.uk

Reserves estimate

- Information supporting mine design (geotechnics, water if relevant, design constraints, proximity of lease boundary to operation, waste dump capacity, etc.)
- Mining modifying factors
  - Mining losses & dilution – how measured, appropriateness of projections, what were the results of the reconciliation?
  - Resource utilisation, minimum mining width, minimum width to exclude waste
- Economic factors:
  - Verification of cut-off grade: average, marginal, operational; strip ratio limits
  - What price is used? Is it a long term price?
- Marketing constraints:
  - Is there a market for the product?
  - Is the production rate constrained by market capacity?
- Social and Environmental constraints:
  - Is mining restricted on any portion of the deposit? Will the community support the project?
- Governmental constraints:
  - Is there any doubt that the government may not grant the necessary permits?

Sergei Sabanov, PhD ssabanov@srk.co.uk

Conclusions

The results of the analysis can be used in estimation of a material balance and technological schemes, and at technological considerations for choosing suitable flowsheets for beneficiation process and selection of mining methods.

These technological considerations are facilitate the appropriate decisions for further oil shale processing and can be useful for oil shale reserves estimation.

Sergei Sabanov, PhD ssabanov@srk.co.uk

Thank You for Your Attention!

Sergei Sabanov, PhD ssabanov@srk.co.uk