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High Purity GRAPHITE

Technology and Market Perspectives

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PDAC 2015

Outline

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1. Introduction – Suppliers and Users Perspectives
2. Major Applications – Critical Performance Parameters
3. Synthetic Graphite vs. Natural Graphite
4. Market Factors
5. Closing Thoughts

INTRODUCTION: SUPPLIERS AND USERS VIEWS

Graphite Market Perspectives

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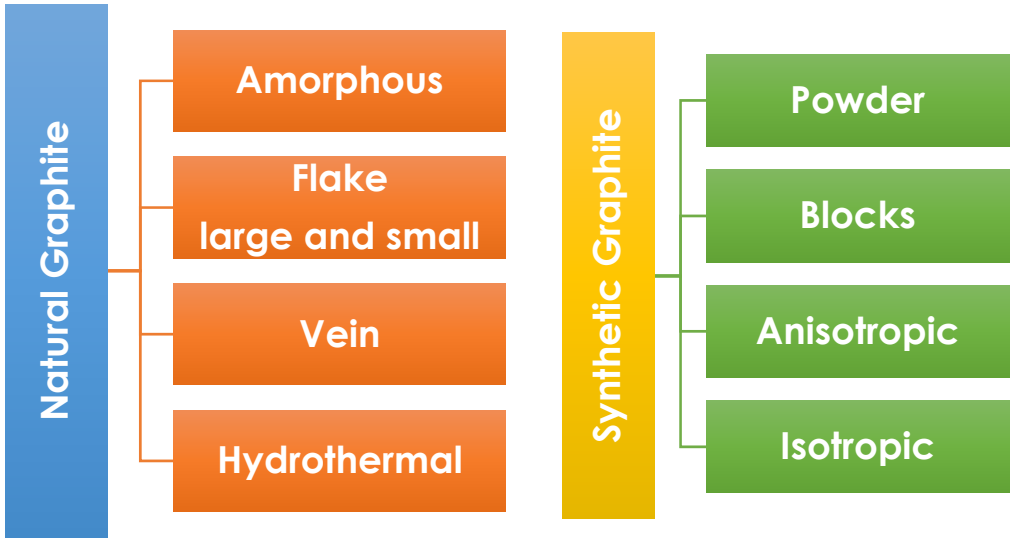
SUPPLIERS VIEW



USERS VIEW

- Functionality
- Processability
- Value-in-use
- Supplier Reliability and Consistency
- Prior Experience
- Supply Chain Complexity

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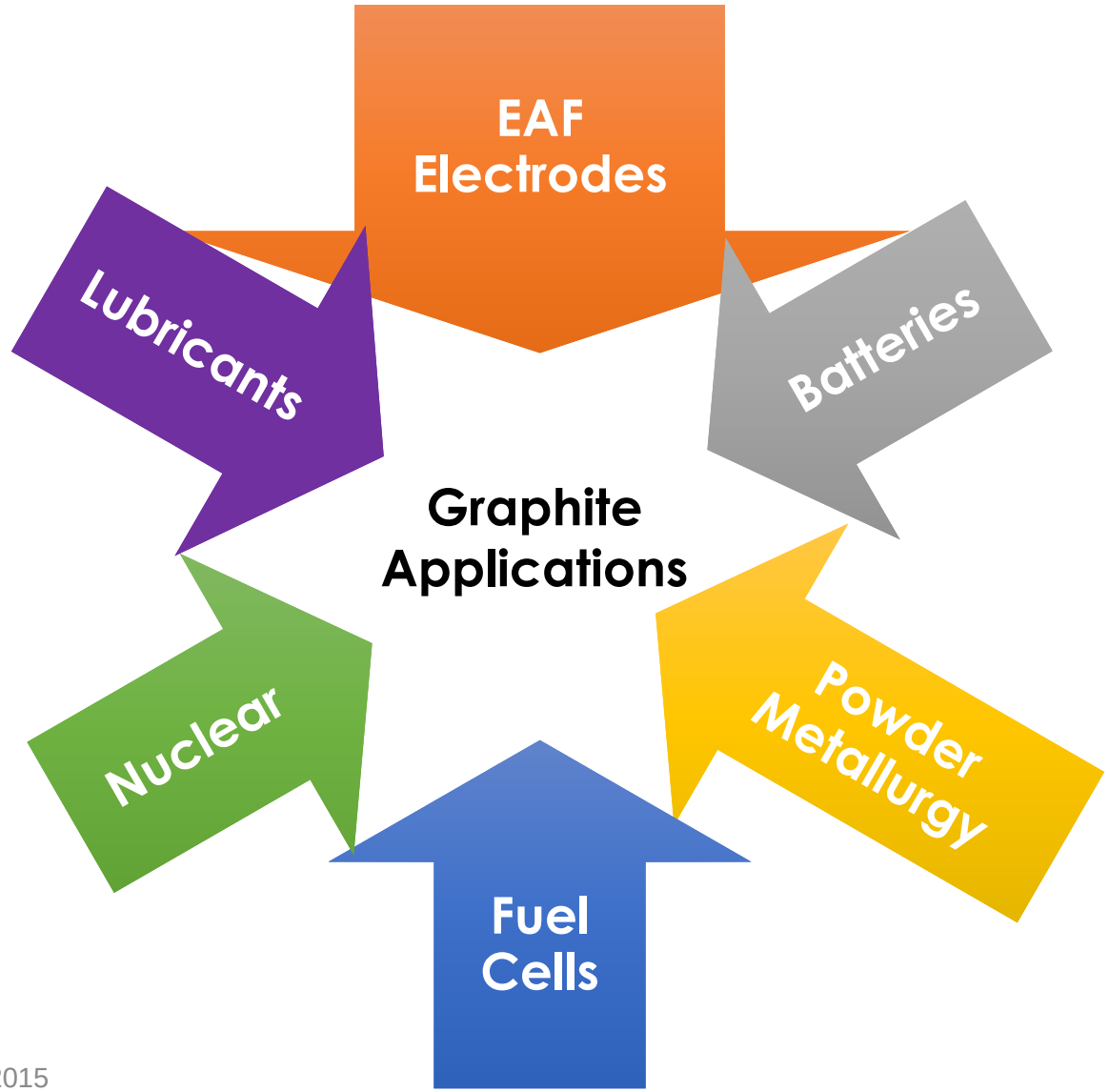
MAJOR APPLICATIONS & CRITICAL PERFORMANCE PARAMETERS

Major Graphite Applications



EAF Electrodes

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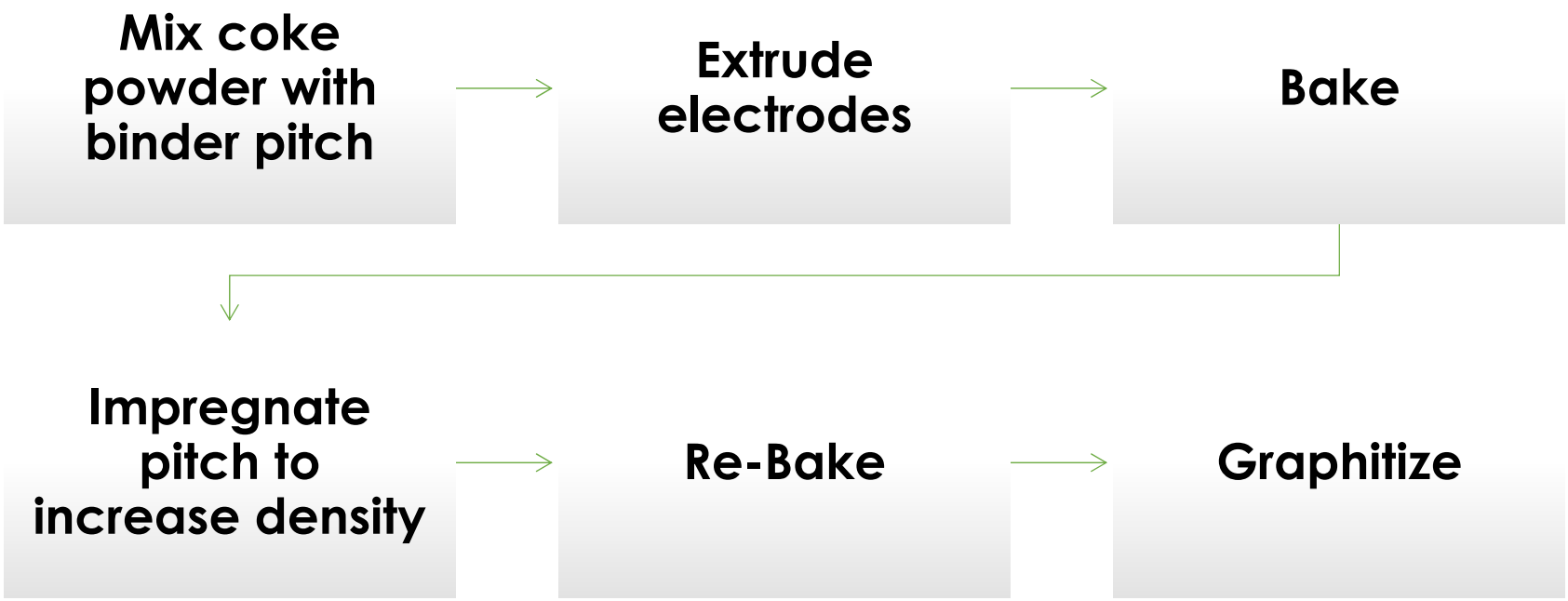
CRITICAL PERFORMANCE PARAMETERS:

- Resistance to Thermal Shock – Low Coefficient of Thermal Expansion (CTE)
- High Electrical Conductivity
- High Structural Integrity
- Low Reactivity

MATERIAL/PROCESSING IMPLICATIONS:

- Final electrode must be 100% graphite
  - All raw materials must be graphite or graphitizable
  - Heat treatment must be the last step
- Raw materials should be highly pure or have volatile impurities
- Electrodes must have high density to maintain structural integrity – zero or low porosity powder
- Easy to process
- Optimize costs by appropriate material selection

EAF ELECTRODES – MFG PROCESS



NG can be used but it is not practical unless needle coke prices are significantly higher than high purity NG

Batteries

- **Three major applications:**
  - Alkaline
  - Li-ion
  - Vanadium Redox Flow (developing)
- **Functionality requirements significantly different**
- **Alkaline Batteries:**
  - Electrical conductivity
  - Reactivity
  - Ease of processing/handling
- **Li-ion Batteries:**
  - Intercalation Capacity
  - First cycle efficiency – Reactivity
  - Ease of intercalation – Power
  - Packed Density
  - Ease of Processing
  - Impurities
- **Vanadium Redox Flow Batteries:**
  - Final artifact properties
    - Conductivity, structural integrity, reactivity etc.

While each battery form has different functionality requirements, any graphite powder with the right properties can be used

Li-ion Anode – Key MFG. Steps

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SYNTHETIC GRAPHITE:

Low impurity coke with ordered structure

- Graphitization
  - Turn into graphite
  - Remove impurities
- Particle Size reduction and classification
  - Improve processing ability
  - Improve rate properties
  - Increase density
- Surface Treatment
  - Improve first cycle efficiency and stability

NATURAL GRAPHITE:

- Raw Material
  - Crystalline graphite
- Particle size reduction
  - Improve processing ability
- Spheridization
  - Improve density
- Purification
  - Either Thermal or Acid Treatment
  - Improve stability
- Surface Treatment
  - Improve First Cycle Efficiency and stability

Significant variations in properties due to different performance requirements and manufacturing needs

Powder Metallurgy

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FUNCTIONALITY:

- Lubricity
- Hardness
- Processability
- Reactivity

PROPERTIES:

- PSD Control
- Purity
- Surface Properties
- Particle Shape

Any graphite powders with right properties can be used

Fuel Cells

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USAGE:

- Bi-Polar Plates in PEM Cells
  - Majority of the Cell Weight
  - Up-to 80% Graphite
- Small quantities in other components

BI-POLAR PLATES:

- X-Y direction Thermal Conductivity
- Z direction Electrical Conductivity
- High Density
- Low reactivity

PROPERTIES:

- High Crystallinity
- Appropriate grain size
- Purity – minimal metallic impurities
- Particle Shape
- Surface properties
- Particle size distribution

Any graphite powders with right properties can be used

Nuclear

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USAGE

- Moderator
- Reflector
- Shielding
- Fuel Coating for Pebble Bed Reactors

FUNCTIONALITY

- Radiation Moderation
- Thermal Conductivity
- Thermal Shock
- Structural Integrity
- Stability

PROPERTIES

- Isotropic properties
  - Small crystalline size
- **Extremely** low impurities
  - Neutron absorbing, oxidation promoting, activation relevant isotopes, metallic corrosion relevant, and fissionable elements
- **Appropriate Particle Shape**
- **Appropriate PSD**
- **Stable Crystal Structure**

Difficult to achieve isotropic properties with most NG materials. Nuclear grade synthetic graphite made from specially produced coke

Isotropic Graphite

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- **Normal Graphite - highly anisotropic**
- **Property ratio in different dimensions can be >>1**
- **Example ratios:**
  - Thermal Conductivity ~200
  - Tensile Strength ~3
  - Elastic Modulus ~25
  - Resistivity ~125
- **Nuclear Applications require anisotropic ratios <1.1 as well as higher density and strength**
- **Current source of Isotropic Graphite is Isotropic Coke**
  - Although refinery based processes exist to produce isotropic coke suitable for nuclear graphite, most of isotropic coke is manufactured by a lengthy process from needle coke or from Gilsonite

Opportunity exists for a pure NG source with the right structure and price to participate in the nuclear graphite market

Lubricants

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USAGE:
- Industrial
- Automotive and Heavy Duty Vehicles
- Specialty Greases
- Forging

FUNCTIONALITY:
- High lubricity
- Appropriate PSD
- Absence of abrasives
- Low moisture content
- Stability

PROPERTIES:
- High crystallinity
- High purity
- Powder with PSD in the desired range
- Low Moisture

MARKET DYNAMICS:
Major synthetic graphite producers are the biggest suppliers due to availability of secondary powder

High purity and crystallinity powder at a competitive price is the key.

Synthetic vs. Natural Graphite

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SYNTHETIC:

- Produced mostly from high grade petroleum coke
- Expensive to produce, but
- Tremendous flexibility in:
  - Processing
  - Particle size
  - Surface chemistry
- Impurities control
- Artifacts production
- Quality
- Consistency

NATURAL:

- Abundant graphite deposits widely scattered across the globe
- Relatively inexpensive to produce, but
- Quality can vary
- Impurities can be a major issue
- Crystallinity may depend on the resource
- Difficult to incorporate in processes
- Cost advantage may be low for artifacts production

Applications where high degree of processing required tend to prefer SG, but NG used widely due to cost advantage

Market Factors

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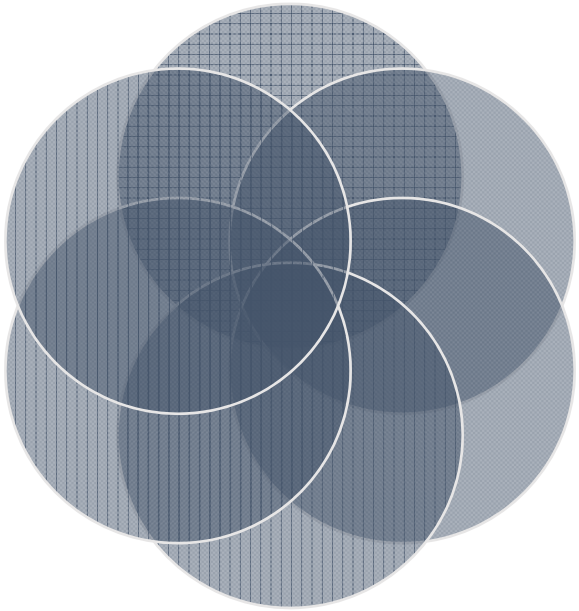
Volume

Existing Supply Relationships



Pricing

Cost of Qualification

Geography and Logistics

Quality, Consistency and Reliability

ZENYATTA GRAPHITE SUMMARY & ADVANTAGES

Zenyatta Graphite

- Igneous-related hydrothermal deposit in Northeastern Ontario
- Location close to major infrastructure
- Robust resource base has been defined
- Metallurgical development work nearly completed and has demonstrated purity of >99.9%
- PEA is in the final stages
- Market development work has been in progress
- Pre-feasibility to begin first half of 2015

Graphite Supply Chain

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Mining
Graphite ore is mined from the deposit

Crushing & Grinding
Simple & low-cost initial process

Flotation
Separate graphite to create a concentrate

Purification
Upgrade concentrate to >99.9% Cg using a simple process

High Purity
Graphite is a key component in many applications
.

Products
Industrial processes, consumer electronics, electric vehicles, fuel cells, power generation, etc.

Zenyatta Graphite- Advantages

- Easy access deposit – no major infra-structure development needed to access markets globally
- Environmentally friendly clean-up process
- Process does not require expensive steps
- Large resource base assures a long-term supply for customers
- Initial feedback in many applications shows suitability of as produced material
- Core market development team in place and building relationships with many global customers

Closing Thoughts

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- High purity graphite has a robust growing market because its essential for many industries, including many new clean-tech applications
- Value-in-use drives the choice of raw material selection
- While processes to incorporate graphite in the end-use product play a role in the raw material selection, the functionality required and properties of the material selected must match
- Other factors do play a role in selections
- Zenyatta is uniquely positioned to participate in many high purity graphite markets due to advantages of size, geography, crystallinity, and easy mineralogy of the resource

THANK YOU!

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ZEN : TSXV

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