



Phelps Dodge's Approach to Technology Development and Innovation

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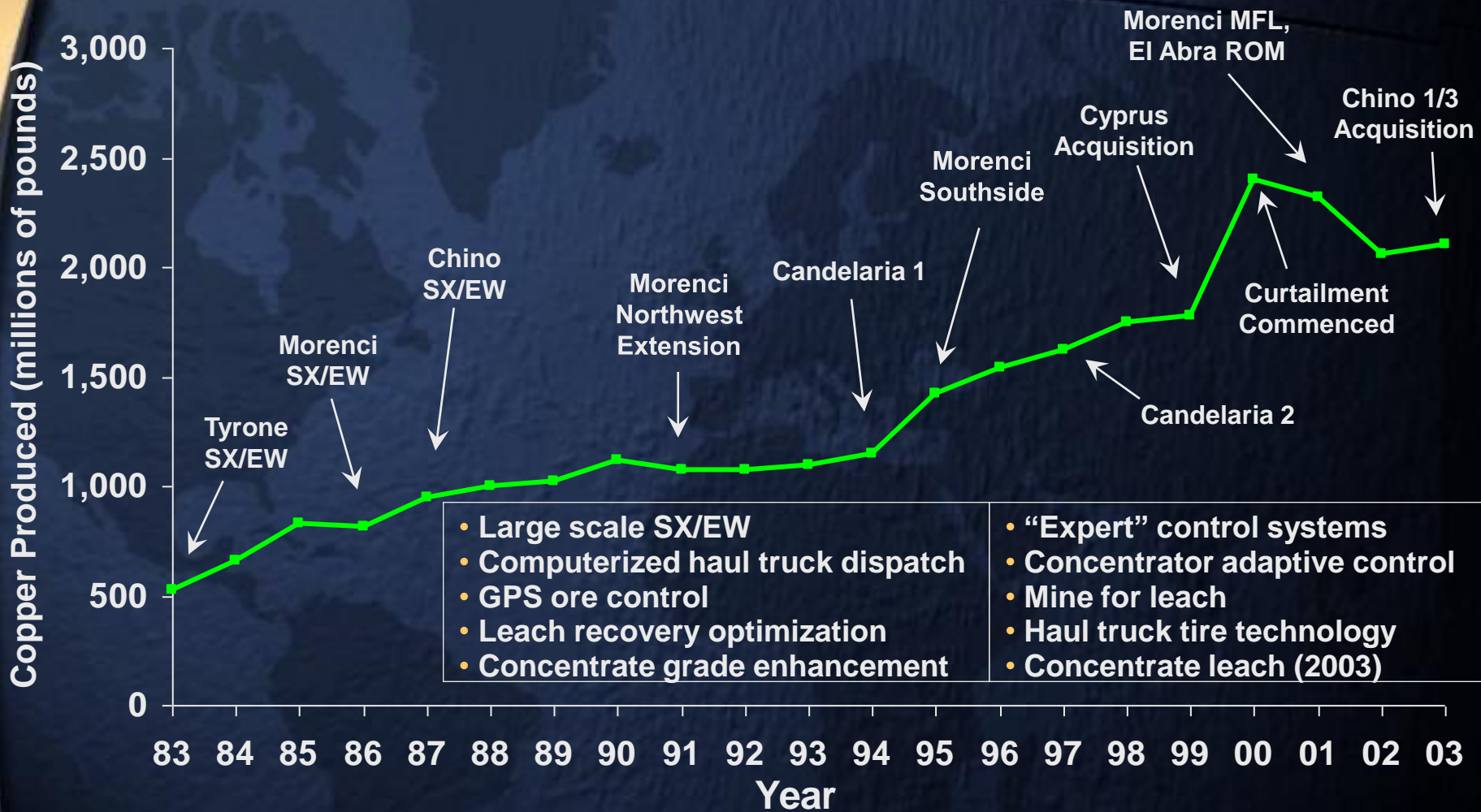
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Introduction

- ◆ Phelps Dodge has a rich history of technological innovation
- ◆ Technology development and innovation can be a real source of competitive advantage within the copper industry
- ◆ Mining industry typically spends between 0.1% and 1.0% of sales revenues on research and technology development
 - Varies dramatically through copper price cycle
 - Varies dramatically by company

Long, Successful Track Record of Technology Deployment



Technology Development - Strategic Guidelines

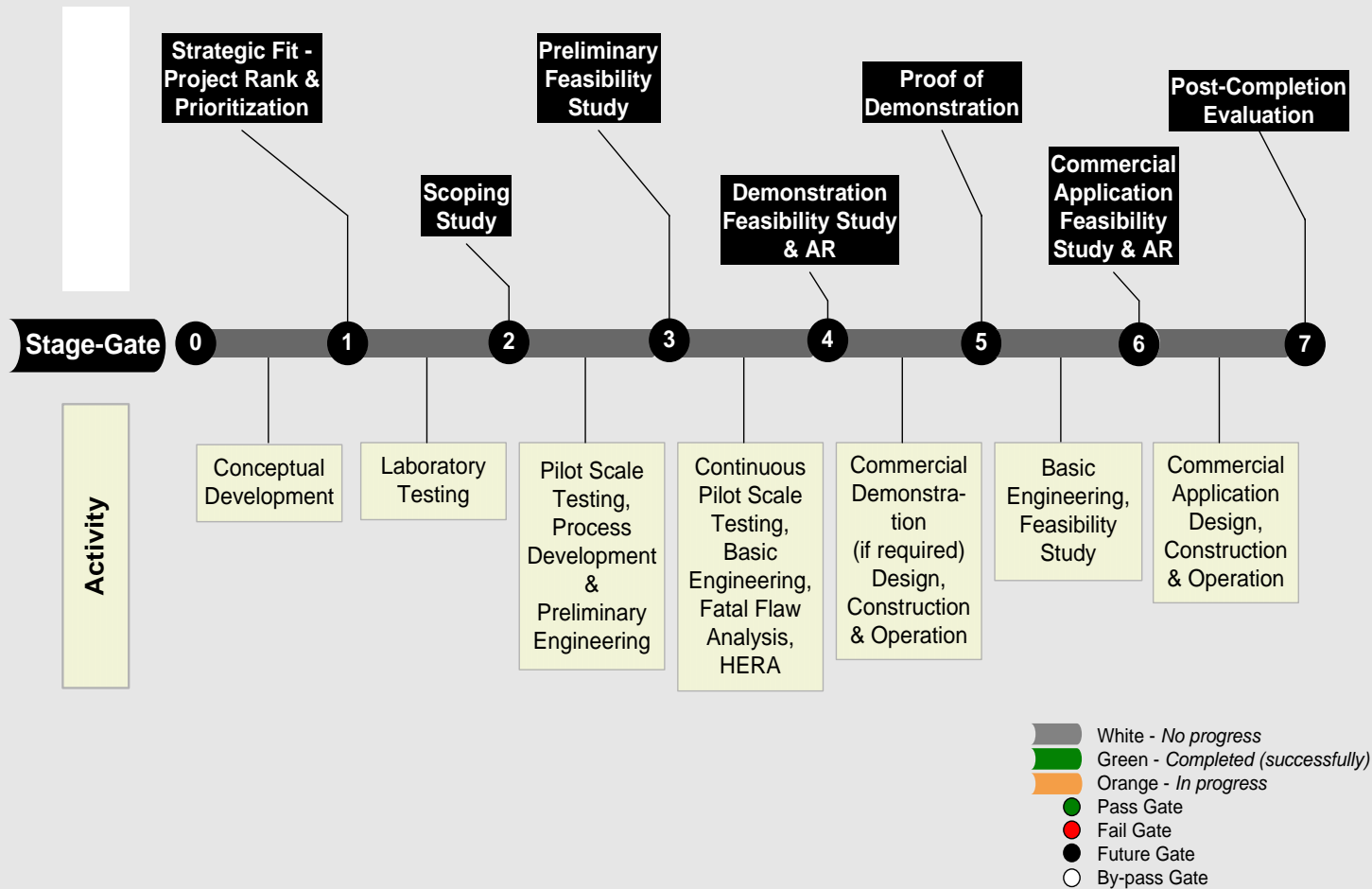
- ◆ Primary focus on copper extraction
- ◆ Focus on applied technology development, not fundamental “research”
- ◆ Center of excellence in selected areas
 - Material characterization
 - Hydrometallurgy
 - Mineral processing
 - Reclamation & remediation
- ◆ Project management rigor
 - Identification, evaluation, ranking, and prioritization of projects
 - Stage-gate process
- ◆ Strong focus on implementation
- ◆ Institutionalization of best practices
- ◆ Strategic partnerships/alliances
- ◆ Collaborative research

Technology Development - Strategic Planning

- ◆ Updated annually
- ◆ Clear vision & mission
- ◆ Identify critical issues
- ◆ Develop projects & programs to address critical issues
- ◆ Prioritize projects & programs
- ◆ Develop execution plans – apply stage gate process
- ◆ Follow up

Stage Gate Process – Technology Development

STAGE - GATE PROCESS FOR TECHNOLOGY DEVELOPMENT



Why Stage Gate?

- ◆ According to study by Hatch/Washington Institute, the **average** commercial success rate for new technology is;
 - One in 3,000 at proof-of-concept/scoping stage
 - One in 30 at pilot plant scale
 - **One in 4 at demonstration scale**
- ◆ Benefits of stage-gate process
 - Manage risk - fail fast or succeed fast
 - Focus resources on best projects
 - Manage technology development costs
- ◆ Downsides with stage-gate process
 - Miss hidden gems
 - Kill too early
 - Limit options



Technology Development – Phelps Dodge's Focus Areas

- ◆ **New transformational step-change technologies**
 - Mining
 - Processing
- ◆ **Continuous improvement of existing operations & technology**
 - Mining
 - Processing
- ◆ **Effective reclamation and remediation in anticipation of closure**

Using Technology to Transform Mining Operations

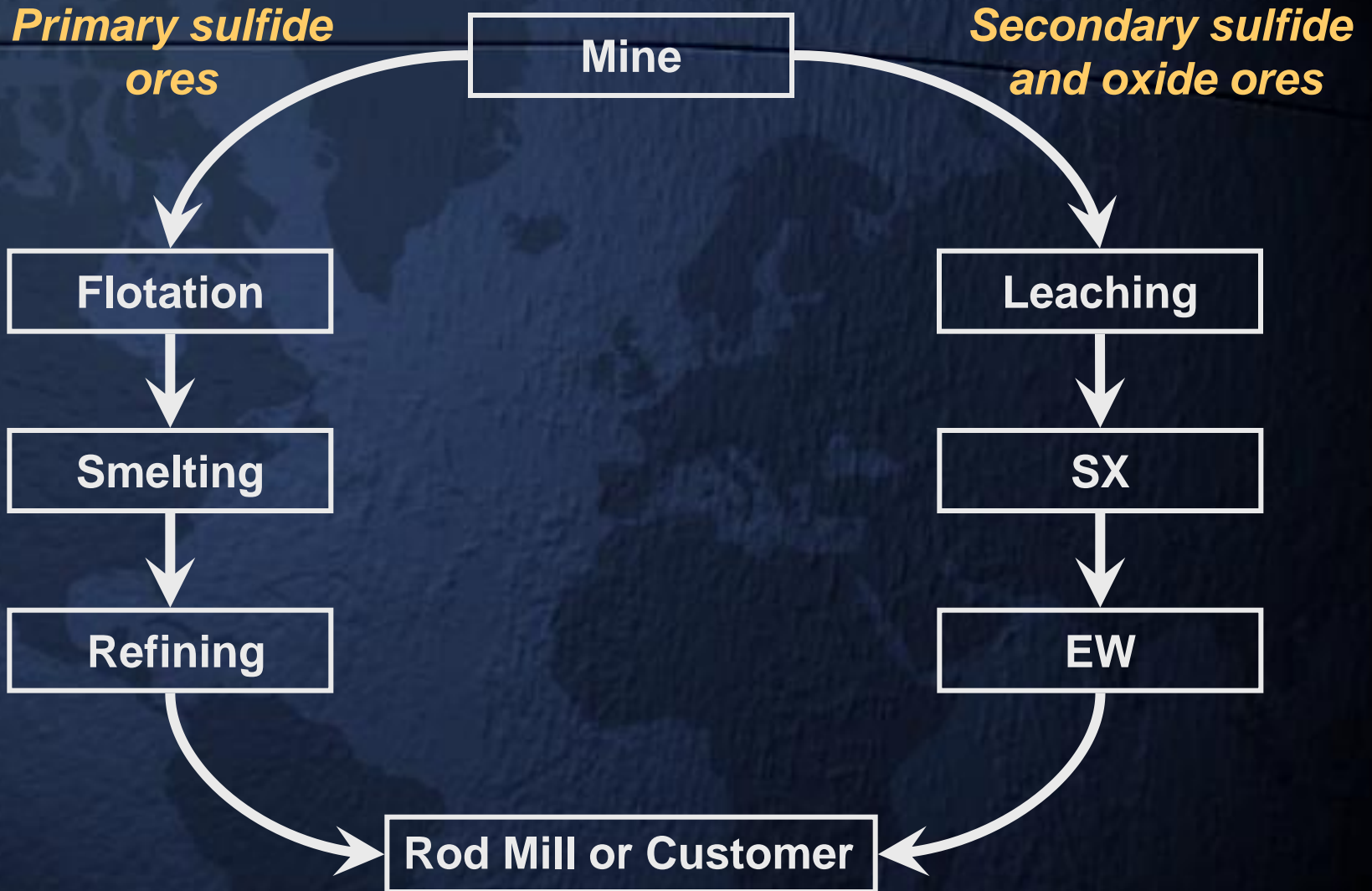
- ◆ High-speed wireless communications
- ◆ Full GPS/inertial navigation
- ◆ Smart autonomous mining equipment
- ◆ Integrated mine management systems – real-time intelligence
- ◆ Continuous mining process
- ◆ Large-scale selective mining with larger equipment
- ◆ Reduced process variance



Using Technology to Transform Processing Operations

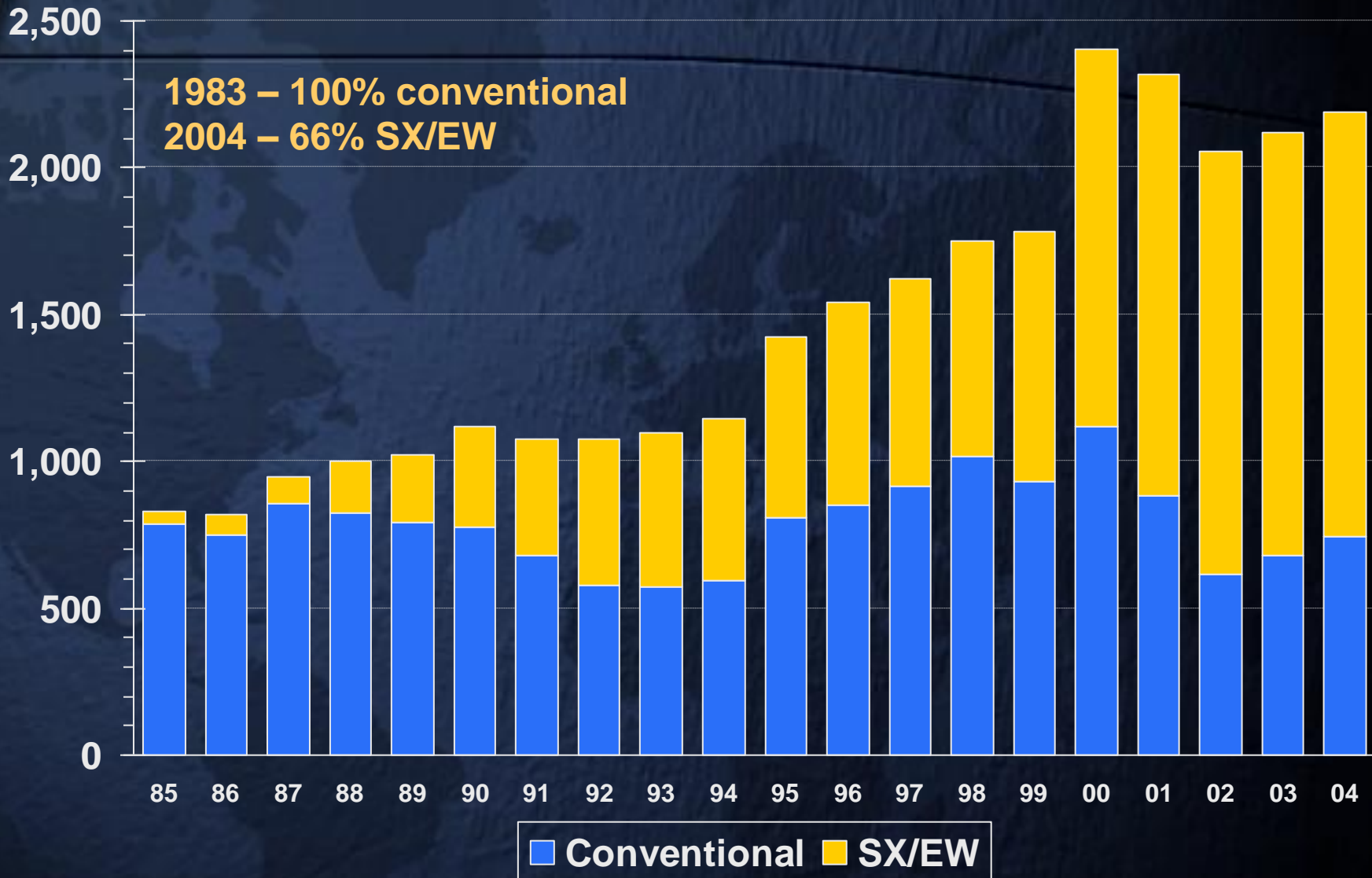
- ◆ **Concentrate leaching, solution extraction and electrowinning**
 - Commercial demonstration proven
- ◆ **Concentrate leaching and direct electrowinning**
 - Commercial demonstration in construction
- ◆ **Leaching of low-grade chalcopyrite stockpiles**
 - Commercial demonstration test in progress
- ◆ **Novel electrowinning technology**
 - Commercial demonstration test in progress
- ◆ **New milling technology**
 - High-pressure grinding rolls to be used at Cerro Verde
- ◆ **Material characterization by “QemSCAN”**
 - Commercial operation & application
- ◆ **Environmental remediation technology**
 - Commercial operation

SX/EW Development in 1980s and 1990s

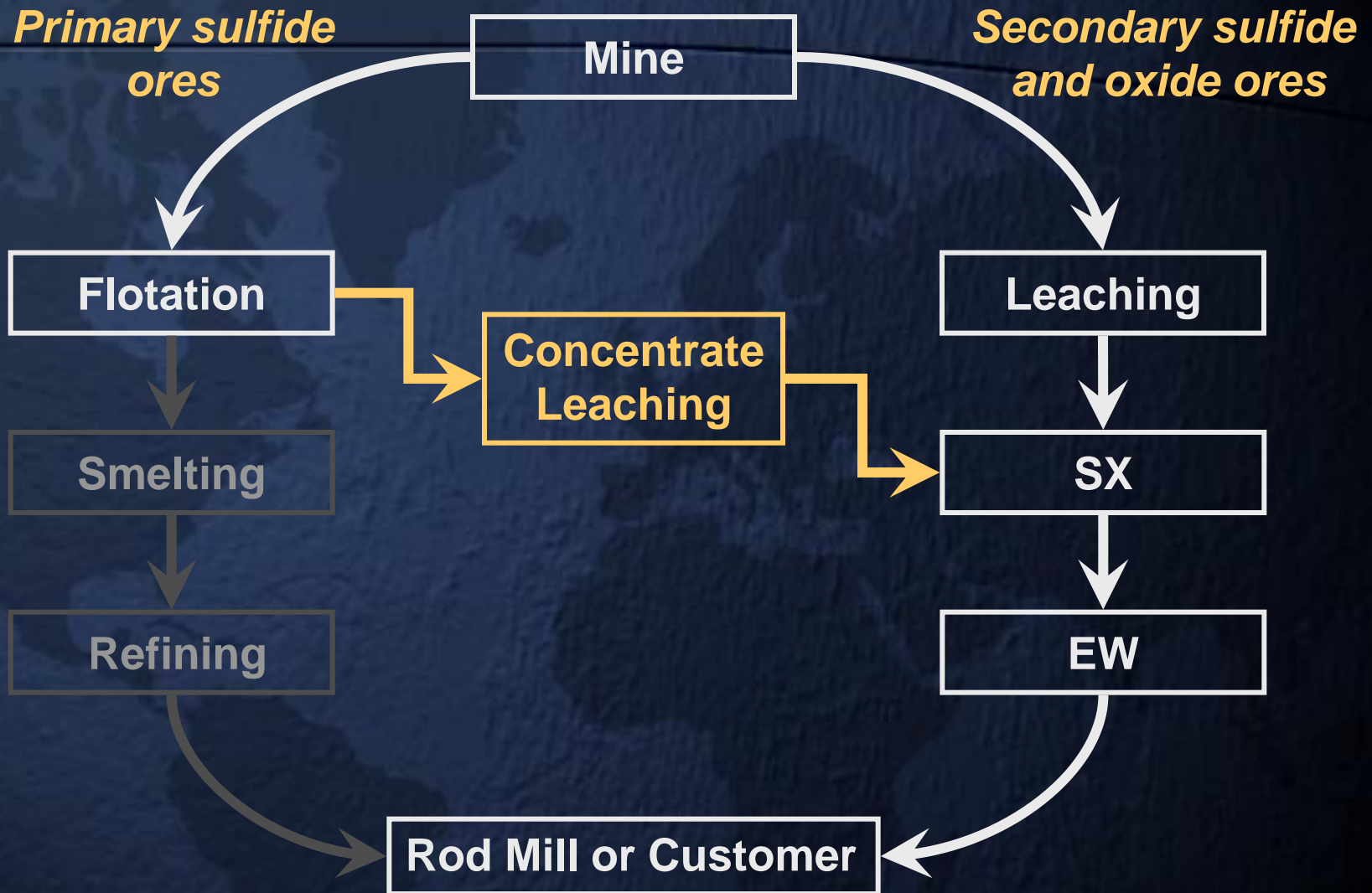


Example of Technology Transforming Copper Production

(PDC share; millions of pounds)



Concentrate Leach Technology Replaces Smelting/Refining

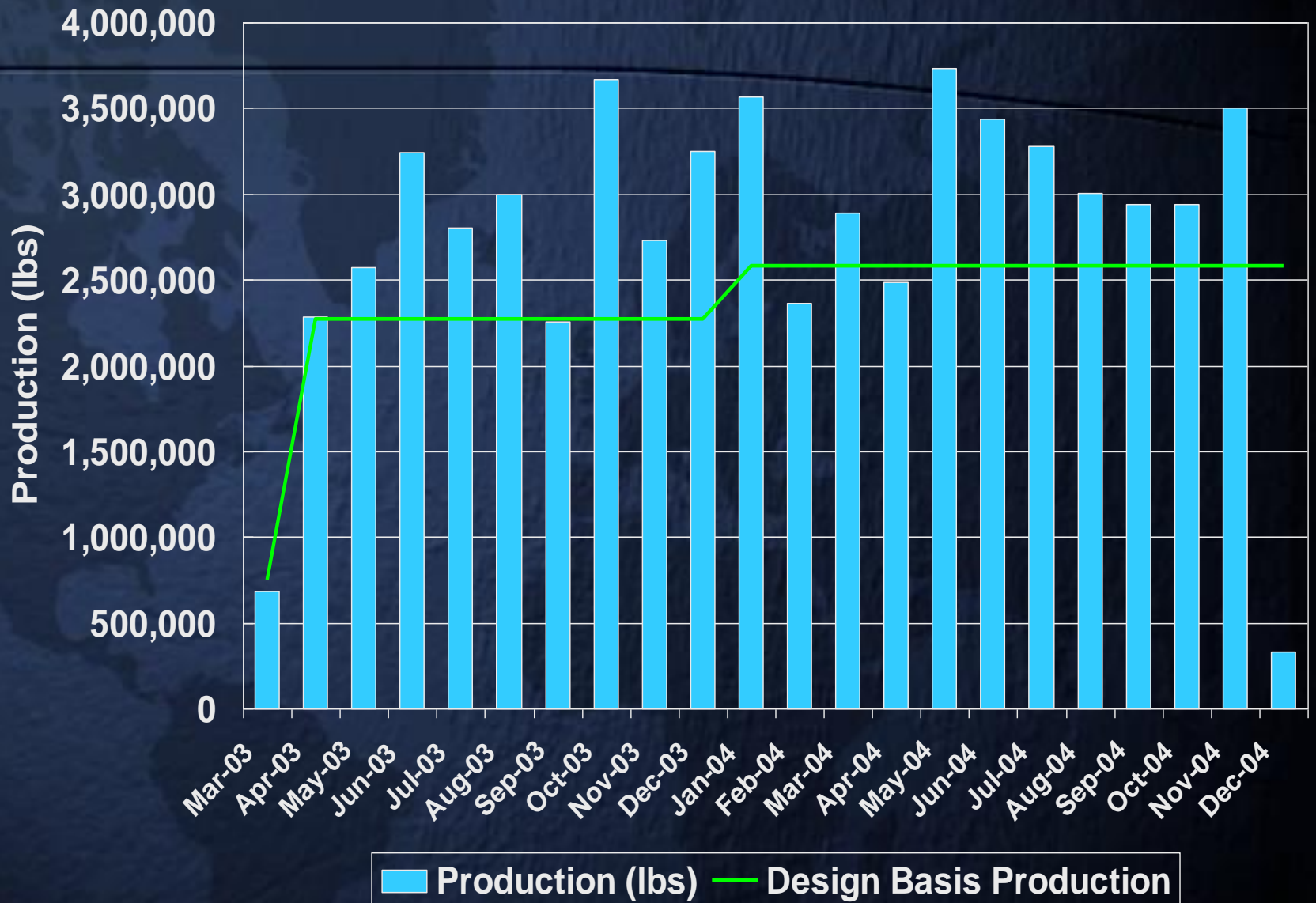


Concentrate Leach Demonstration Plant at Bagdad



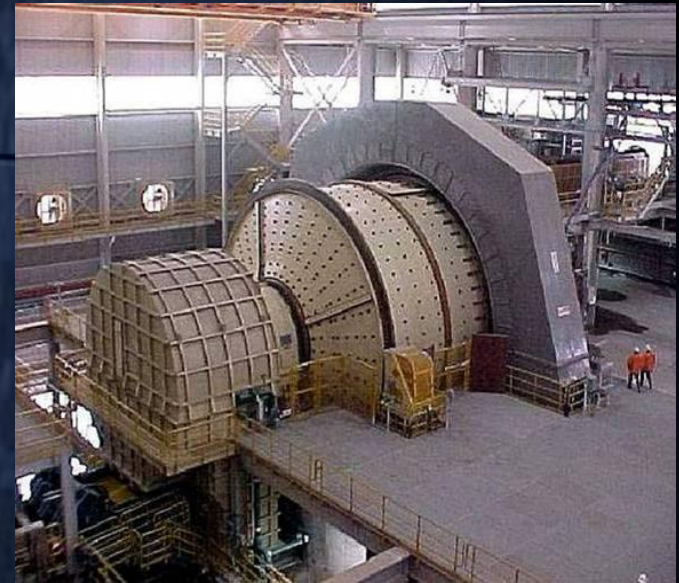
Safety: Zero recordable injuries since December 20, 2002

Bagdad Concentrate Leach Plant Copper Production



High-Pressure Grinding Rolls

- ◆ Cerro Verde milling circuit to include high pressure grinding rolls (HPGR) instead of SAG mills
- ◆ Pros
 - Higher throughput
 - Greater energy efficiency
 - Greater flexibility
 - Lower unit cost
- ◆ Cons
 - Additional capital cost
- ◆ Financial Impact
 - Significantly reduces power consumption and unit production costs

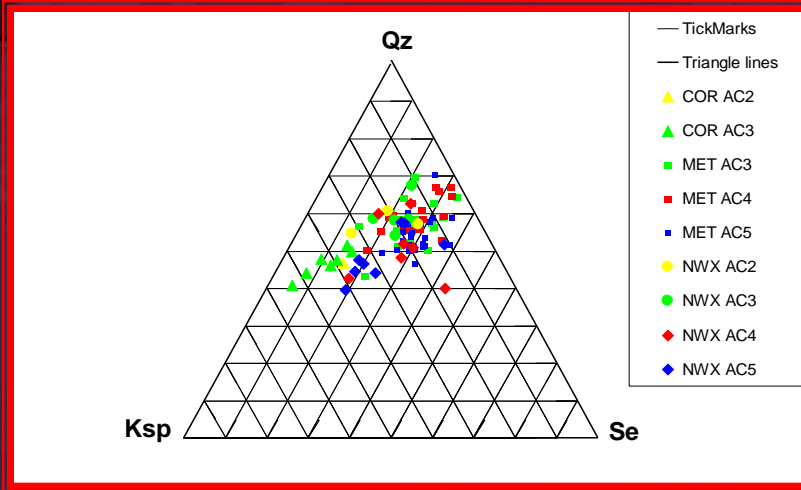


Material Characterization – QemSCAN Technology

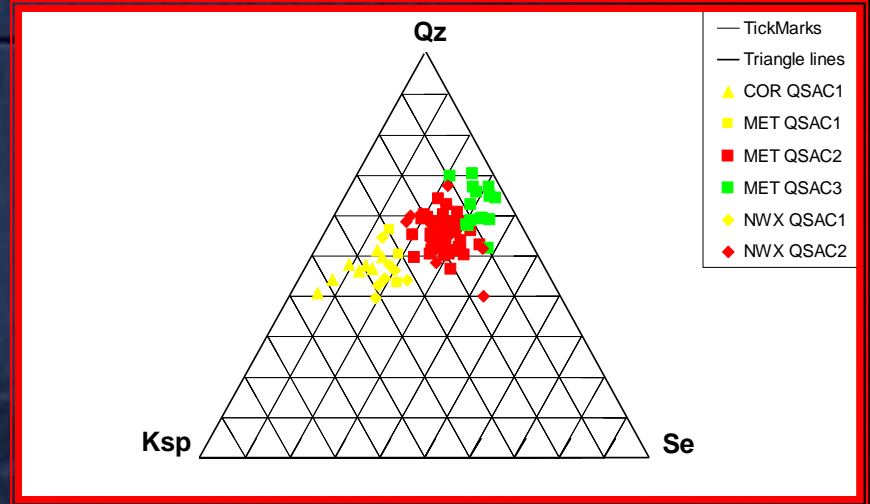


Using QemSCAN Data to Improve Decisions

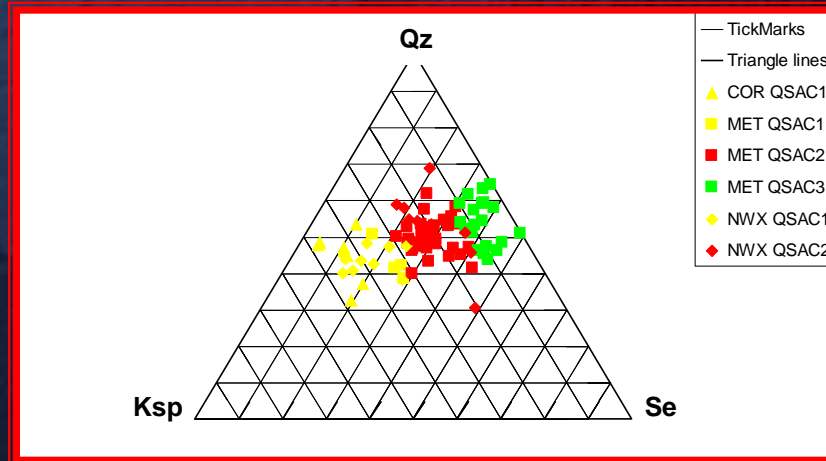
Morenci Alteration Codes – QemSCAN Data



QemSCAN Alteration Codes – QemSCAN Data



QemSCAN Alteration Codes – XRD Data



Precision and accuracy of data greatly improved

Improves:

Ore control & ore type routing

Process control

Mine design & sequencing

Plant design

Key Enablers for Effective Technology Development

- ◆ **Champion(s)**
 - Vision, capability, experience, dedication
- ◆ **Infrastructure/Environment**
 - Research & development facilities
 - Operational excellence
 - Technology implementation capability
- ◆ **Resources**
 - People, money, time
 - The devil is in the details
- ◆ **Ability to manage expectations**
 - Communication to key stakeholders
- ◆ **Economic conditions**
 - Maintain initiatives through industry downturns
 - Make hay when the sun shines
- ◆ **Long term perspective**
- ◆ **Senior management, Board, shareholder commitment**

***phelps
dodge***

Thank You

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