Sustainable Development and Natural Resources

EurGeol Garth Earls
Director, GSNI

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Revegetation of mineral sand dunes

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Structure of Presentation

• What are Natural Resources?
• Perceptions and Reality
• Natural Resources and the Sustainable Development Paradigm
• Examples of SD and Natural Resources
• The Tellus Surveys – knowledge based decision making
• Conclusions

Some text and images courtesy of David Groves, Jeremy Richards and Mike Petterson
What are Natural Resources?

Natural resources can be thought of in five overlapping ways. Each of these reflect values that we associate with them:

1. Raw materials – minerals, hydrocarbons and biomass
2. Flow resources – geothermal, wind, tidal and solar energy
3. Environmental - water, soil and air
4. Space is required to produce or sustain all the above
5. Biological - species and genetic information
• Geothermal map

• Hydrocarbon

• Water map

• Soil map

Geological Survey of Northern Ireland
Sustainable Development

1. Has arisen because of population increase and land and many resources are finite

2. It is about getting a balance between development, government, society and environment by trying to equitably share development benefits

3. It is also about doing more with less, developing in a less consumer-intensive manner and reducing waste streams

4. But.....there is a lot of rhetoric and hiding behind language rather than finding real solutions
GDP/Head (US$)

- USA
- Japan
- Ireland
- EU12
- UK
- Poland
- Russia
- Brazil
- Nigeria
- Kenya
- Zimbabwe
- World
- India
- Bangladesh

(US$)
Energy Consumption/Head (Kg Oil Equivalent)

- USA: 8000
- EU12: 4000
- Japan: 4000
- UK: 4000
- Ireland: 3000
- Russia: 2000
- China: 1000
- India: 1000
- Brazil: 1000
- Bangladesh: 1000
- Zimbabwe: 1000
- Kenya: 1000
- World: 1000

Source: Geological Survey of Northern Ireland
World Population - 6.14 billion

- India
- China
- USA
- Brazil
- Bangladesh
- Zimbabwe
- Kenya
- Russia
- UK
- Poland
- Japan
- EU12

World Population: 6.14 billion
1. Evolution is development; all species are designed to develop and flourish, usually at the expense of other species. But growth is normally self-limiting - unsustainable populations will die back or become extinct.

2. No development and no life-form has zero impact on the environment, but the environment on this planet has an extensive ability to absorb change.
3. The human population is projected to grow 50% by 2050 (from ~6 bn to ~9 bn). Is this sustainable? Why is no-one seriously addressing this question?

4. Newly mined materials will be essential to support this growing population. It is estimated that 5x the amount of metal mined in the world to date must be mined in the next 50 years to satisfy this growth.

5. 5% of the world’s population consumes 30% of the world’s mineral wealth.
6. Laudable objectives of reducing poverty imply significant increases in raw materials usage to build infrastructure and meet new consumer demand in developing countries.

7. Per capita consumption rates in the developing world are growing fast, and would be huge if they matched US rates.

8. Recycling cannot satisfy this demand when population and per capita consumption are growing.

Thus, we have no option but to continue mining...
Living requires materials

If you cannot grow it

You have to extract it
Protesters dig in to save landscape from quarry: ‘It’ll cost millions to get us out’
Paradigms

I want a new house

I want to wear gold jewellery

I want a car

Explore somewhere else for zinc

I don’t want gas exploration, wind farms or power stations near me

Canadian Pro Mining Awareness Slogan

BAN MINING....

LET THE B了解一下S FREEZE IN THE DARK!
Restoration
Mineral Reserve/Resource evaluation
Mineral exploration
Re-use (agriculture, nature conservation, forestry, residential, industrial)
Mineral Exploration
Restoration
Land

Department of Enterprise, Trade and Investment
Geological Survey of Northern Ireland
Sustainable Development
What does it mean in the context of the minerals industry?

• Development must not exhaust the natural environment’s ability to absorb change.
• A sustainably developed mine will leave no post-closure liabilities.
• Ideally, development will leave a net positive environmental legacy (e.g., parks, wetlands, fertile farmland, enhanced biodiversity, removal of natural contaminants).
• Development must not sterilize resources for future generations (e.g., by high-grading, careless infrastructure development and urban planning).
Sustainable Development
What does it mean in the context of the minerals industry?

• Development must leave a net positive, equitable, social legacy.

• Development must create net wealth that accrues to *all* genuine stakeholders. Stakeholders who are impacted by development or whose resources are being exploited must be properly compensated.

• Creative compensation packages that include training and investment should be implemented to ensure that sustainable societies are left after mining is complete.
Sustainable Development Models and Opportunities within the Minerals Industry

Extraction Techniques

- 4% of world’s energy consumption used to crush and grind rocks and minerals. Up to 7% if smelting included
- Improve efficiency and recovery
- Develop new mineral processing techniques
- Develop safer processing methods and reagents
Sustainable Development Models - Opportunities in the Minerals Industry

Environmental Control and Management

* Probably < 0.1% of world’s land surface disturbed by mineral extraction — point source disturbance, and very small compared with forestry and farming
  - Upside potential: improvement of water quality, habitat
  - Increased biodiversity potential in reclaimed lands

*e.g. British Columbia, Canada:
~0.1% of land area disturbed by mining, compared with 51.5% designated as productive forest, >4% harvested since 1981 (Mining Assoc. B.C., 2001; B.C. Ministry of Forests, 2000)
Geoscientists and Sustainable Development

- Geoscientists have much to offer in the field of sustainable development, because we have expert knowledge of many of the natural processes that give rise to environmental problems.
Minerals and Sustainable Development in Northern Ireland

Geological Survey of Northern Ireland
McConnell and Sons of Kilkeel

“The head of a County Down firm which constructed a new memorial to the armed forces in Staffordshire has spoken of his pride at its completion.”

BBC News, Friday 12 October 2007
Indigenous Resources – International Reputation

J. C. Bloomfield

© Fermanagh County Museum  © Harrison Photography  Erin – Belleek Pottery

Geological Survey of Northern Ireland
Post Closure
Uses
Historic Landmarks reflect Local Stone
Albert Memorial – Newry Granite Pedestal and some Columns
Mining and Quarrying – a transient land use

Curraghinalt Gold Mine, Co. Tyrone, 1988

Curraghinalt Gold Mine, Co. Tyrone, 2004
Sustainable Development Models and Opportunities within the Minerals Industry

Mineral Exploration

- Improve discovery rate through application of innovative exploration methods
- Develop predictive exploration models
- Identify new resource types
- Demonstrate responsible community engagement and environmental awareness from the outset
- Knowledge based decision making

"De re Metallica, 1556"
Ireland – Operating Mines

- Carrickfergus - salt
- Cavanacaw – Au
- Tara – Zn Pb
- Galmoy – Zn Pb
- Lisheen – Zn Pb
<table>
<thead>
<tr>
<th></th>
<th>Tonnes</th>
<th>g/t Au</th>
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<tbody>
<tr>
<td><strong>Proven Reserve</strong></td>
<td>181,480</td>
<td>7.36</td>
</tr>
<tr>
<td><strong>Probable Reserve</strong></td>
<td>185,830</td>
<td>7.68</td>
</tr>
<tr>
<td><strong>Indicated Resource</strong></td>
<td>1,183,680</td>
<td>7.02</td>
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</tbody>
</table>

4.3m @ 7.87 g/t Au including 1m @ 27.42g/t Au
Curraghinalt Deposit

43-101 compliant inferred resource
527,700 tonnes grading 15.45 g/t Au; 6.0 g/t Au cutoff
How to Form a Mineral Deposit

- Source
- Pathway
- Receptor
Anatomy of a Hydrothermal System

Host rock
Channelway (major fault)
Structural permeability
Fluid focusing
Source rock

Surface to several km
Several km
Schematic cross section of Dalradian- Tyrone Igneous Complex relationships

Dalradian migméocline thrust ESE over arc

Cavanacaw Curraghinalt

Slieve Gallion granite syn-wet sediment in arc and hybridises with ophiolite gabbro

Arenig-Llanvirn ophiolite (472Ma)

Dalradian and arc imbricated

Laght Hill Tonalite emplaced late in arc deformation

Pre-640Ma continental crust

Ophiolite obduction towards NW

Department of Enterprise, Trade and Investment
Geological Survey of Northern Ireland
Ordovician Arc
New Brunswick - Newfoundland - Co. Tyrone
FIG. 2. Schematic stratigraphy of the Miramichi, California Lake, and Tetagouche Groups, showing the age relationships between the northwardly stacked nappes present in the Bathurst Mining Camp (modified after Rogers et al., 1997).
Soil Geochemistry

\[ \text{Au} \]

- 40 ppb
- 2 ppb

Ct

Cw

0 - 20km

TELLUS

Building Sustainable Prosperity

Geological Survey of Northern Ireland
Geology of the Southern Sperrin Mountains

Curraghinalt

Cavanacaw
Host rock

Structural permeability

Fluid focusing

Source rock

Channelway (major fault)

Receptor

Pathway

Source
Gold in soils

- Draperstown Lineament
- Omagh Lineament
- Omagh Thrust
- Orlock Bridge Fault

- 40 ppb
- 2 ppb

Geological Survey of Northern Ireland
The Omagh Lineament and the Draperstown lineament focus Ordovician-Silurian and Carboniferous fluids.

The last movement on the Omagh lineament was c. synchronous with the emplacement of the Irish Zn-Pb deposits.
Tyrone and Fermanagh EM

Curraghinalt

Cavanacaw
Applications of the Tellus data to other minerals

- Nickel

Figure 1. Generalized model for formation of sulfide deposits rich in nickel, copper, and platinum-group elements. Modified from Naldrett (1989).
Nickel in soils

Shanmullagh Formation

Lough Erne Dyke

Gala Gp 3-7

Antrim Basalts

Co Down Dyke Swarm

0.4 ppm

360 ppm

0 20 km
NE Antrim
Nickel in soils and magnetics
0.4 ppm - 360 ppm
0 - 20 km

Tellus
Building Sustainable Prosperity
Geological Survey of Northern Ireland
Committed Mineral Exploration expenditure <£0.5 million
Committed mineral exploration expenditure £17 million

Over 50% under licence or application
Mineral Exploration and Mining – Good or Bad?

- Exploration is essentially non invasive
- Less than 0.1 % of planet Earth is affected by mining
- Extractive industries are a transient land use
- Former mining sites are now World Heritage Sites
- Need to stop thinking in human life cycles
- The Landscape is dynamic – we don’t like change
- We need minerals to live
Groups of Indicators

1. Economic Sustainability
   - Sustainable economic performance
   - Economic impacts of the industry
   - Employment impacts of the industry

2. Environmental Sustainability
   - Natural resource protection
   - Environmental strategy
   - Manage local environmental impacts

3. Social Sustainability
   - Internal stakeholder relations
   - External stakeholder relations
<table>
<thead>
<tr>
<th>OLD</th>
<th>NEW</th>
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<tbody>
<tr>
<td>Polluter pays</td>
<td>Pollution prevention</td>
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<tr>
<td>Tangential</td>
<td>Strategic</td>
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<tr>
<td>Regulation and compliance</td>
<td>Rights and responsibilities</td>
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<td>Crisis–management</td>
<td>Precautionary approaches</td>
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<tr>
<td>‘Do no harm’</td>
<td>‘Guarantee positive good’</td>
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<tr>
<td>Public Relations</td>
<td>Social Reporting</td>
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<tr>
<td>Description</td>
<td>Indicators</td>
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<tr>
<td>Regulatory Drivers</td>
<td>Financial Drivers</td>
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Source: Alyson Warhurst, Warwick University
Conclusions 1

• Unless we deny the development of the human species, the need for newly mined mineral resources will continue.

• Exploitation of such resources should be planned and conducted in such a way that:
  
  • Net benefits accrue fairly to all stakeholders;
  • The environment is not impacted beyond its capacity to absorb change;
  • Post-closure legacies are negligible or even positive.
Conclusions 2

• Geoscientists have a leadership role to play in ensuring sustainable development of natural (and especially mineral) resources

• The breadth of science experience allows geoscientists and almost unique perspective on all aspects of the extractive industry cycle - from exploration through development, to closure and reclamation

• Tellus was designed to help, support and manage development of natural resources in an environmentally responsible manner
Pinatubo - two days in 1991

- 10 billion tons of magma
- 20 million tons SO₂
- 800,000 tons Zn
- 600,000 tons Cu
- 550,000 tons Cr
- 300,000 tons Ni
- 10,000 tons As
- 1,000 tons Cd
- 800 tons Hg

60 volcanoes erupt per day
>3,000 vent fields at mid ocean ridges