Independent Assessments of Gold, Phosphate, Potash, Uranium, and Rare-Earth Deposits in Australia, Vietnam, Texas and Alaska

by

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Jupiter, Florida

An Invited Lecture Presented to the Houston Geological Society At the Environmental and Engineering Group’s Dinner Meeting

March 9, 2016
Version 1.5
Gold, Silver, Uranium, Phosphate, Potash, and Rare-Earth Deposits

Here is what we’ll cover:

- Gold, and other Commodities on Properties in Queensland, Australia
- Phosphate and Potash Properties in Queensland Australia
- Uranium Properties in South Australia and Texas
- Gold Properties in North Vietnam
- Uranium, Thorium, and Rare Earth Property in Alaska

Meetings in Mexico City .................... and Meetings in the Outback of Queensland
I2M Assessments

White Mountain Project:
Northeast Queensland, Australia
N 43-101- Competent Persons Report (CPR)
for:
Wishbone Gold Pty Ltd.
Southport, Queensland
Australia

Blue Doe Project:
Northeast Queensland, Australia
N 43-101- Competent Persons Report (CPR)
for:
Brumby Group Pty Ltd.
Southport, Queensland
Australia

Iron Glen Project:
Northeast Queensland, Australia
Competent Persons Report (CPR)
for:
Alenby Capital Limited
Strategic Minerals plc
London, England

Wishbone II Project:
Northeast Queensland, Australia
N 43-101- Competent Persons Report (CPR)
for:
Wishbone Gold Pty Ltd.
Southport, Queensland
Australia

I2M Associates, LLC
Houston, Texas and Seattle, Washington
February 2012
Version 1.2

by
Michael D. Campbell, P.G., P.H.
and
Jeffrey D. King, P.G.

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I2M Associates, LLC
Houston, Texas and Seattle, Washington
January 29, 2012
Version 1.2

Reports
Mineral Districts in Australia

Associated with Granitic and Alkaline Magmatism

Projects Discussed

Base Map From Champion and Bultitude (2013)
Assessments Conducted by I2M Associates, LLC
Northern Queensland
The Bluff Area

North of The Bluff Area

Satellite View of The Bluff
Ravenswood-Welcome Gold Trend

Northern Queensland

- Mining Tenement Holdings
- Major Gold Mines and Known Prospects
- Subject Tenements

- Resolute Mining Limited (Ravenswood & Mt. Wright Mines & Welcome Deposit)
  w/ Exploration via Carpentaria Gold Pty Ltd
Geological Map in Area of Wishbone Tenements
Northern Queensland

- Processed Aeromagnetic Map
- Major Gold Mines
- Identified NE Gold Trends
- New NW Gold Trend
- Subject Tenements
Northern Queensland

- Advanced Geomagnetics Map
- Selected Areas of Interest
- Shear Zones
- Known Gold Mineralization
The Welcome Deposit

- Next Mine for Resolute Mining Ltd.
- Underground Mine
- Mine Plan Similar to Mt. Wright Mine
Welcome Deposit

Northwest Trend

Northeast Trend

Aerial Magnetics Map Available from the Queensland Government
Northern Queensland

Prevailing Gold Mineralization Models in Australia

EPITHERMAL CLAN

Near Surface

Deep Seated

INTRUSION-RELATED CLAN

From Hannington, et al., 1999
Northern Queensland

Gold Mineralization Models in Queensland

Mines and Deposits Typed

After Beams, 2012
Northern Queensland

On the Ground within the Wishbone II Tenement

The Queensland Outback During Spring “Wet” Period

Dry Creek Outcrop of Granite
Northern Queensland

Thin Sulfide Veins in Shear Zones
(see Tables for Gold and other Metal Values)
## Northern Queensland

### Haughton Bluff Creek West to DAB Veins Area
#### Northern Area of Wishbone II

#### Rock-Chip Samples

<table>
<thead>
<tr>
<th>SAMPLE #</th>
<th>COPPER %</th>
<th>LEAD PPM</th>
<th>ZINC PPM</th>
<th>SILVER PPM</th>
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<td>274</td>
<td>137</td>
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<tr>
<td>3019141</td>
<td>5,490 ppm</td>
<td>8.0</td>
<td>120</td>
<td>13.8</td>
<td>0.14</td>
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</table>
## Northern Queensland

### Oaky Creek Area

#### Central Area of Wishbone II

**Rock-Chip Samples**

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<thead>
<tr>
<th>SAMPLE #</th>
<th>COPPER PPM</th>
<th>LEAD PPM</th>
<th>MOLYBDENUM PPM</th>
<th>ZINC PPM</th>
<th>ANTIMONY PPM</th>
<th>SILVER PPM</th>
<th>GOLD PPM</th>
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<td>1.510 ppm</td>
<td>5</td>
<td>1,830 ppm</td>
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<td>3.930 ppm</td>
<td>3.2%</td>
<td>1</td>
<td>126</td>
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<td>0.03</td>
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<tr>
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<td>10</td>
<td>389</td>
<td>9</td>
<td>56</td>
<td>0.16</td>
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<tr>
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<td>2770 ppm</td>
<td>674</td>
<td>239 ppm</td>
<td>214</td>
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<td>31</td>
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<td>3011374</td>
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<td>2.7%</td>
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<td>30</td>
<td>3</td>
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<td>3011375</td>
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<tr>
<td>3011376</td>
<td>6.3%</td>
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<td>142</td>
<td>3</td>
<td>11</td>
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<tr>
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<td>476</td>
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<td>0.01</td>
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<tr>
<td>3014136</td>
<td>3.6%</td>
<td>2</td>
<td>3</td>
<td>351</td>
<td>3.6%</td>
<td>4</td>
<td>3.5</td>
</tr>
</tbody>
</table>
Northern Queensland

Heading for Mt. Wright to the South

Entrance to Underground Mine
Northern Queensland

Mt. Wright Mine

After Resolute Mines, Ltd.
Northern Queensland

Ravenswood Mine Area

Trucking Ore from Mt. Wright Mine

Processing System

Primary and Secondary Crushers
Northern Queensland

Wishbone

White Mountains
Heading toward White Mountains Area, Queensland

River in Flood

Black Swan

Volcanics
White Mountains Area, Queensland

Aerial Magnetics Map of Tenement Area

Ground Magnetics Surveys Tenement Area
White Mountains Area, Queensland

Other Tenements Surrounding Subject Tenement
Showing Historical Prospect Areas
White Mountains Area, Queensland

Adjacent Tenement Activities (Drilled and Resource Estimated)
White Mountains Area, Queensland

On the Ground and in the Creek

Brolga Cranes
White Mountains Area, Queensland

Reviewing Adjacent Ground IP and Magnetics Survey Interpretations
White Mountains Area, Queensland

Dike Outcrops

Historical Workings

Laboratory Analyses

Laboratory Analyses
White Mountains Area, Queensland

Massive Antimony Sulfide (Stibnite)

Laboratory Analyses

Anomalous in Antimony and Copper
White Mountains Area, Queensland

Geologic Map

Enhanced Google Map of Area
White Mountains Area, Queensland

Current Models of Mineralization for Northern Queensland

Beams, 1995
Note: I2M Associates is mentioned at 4 minutes 12 seconds into the above 2012 presentation.

Update 2014 InterGroup Mining Ltd. Presentation (more)
Phosphate in Queensland .... and Northern Territory

Map showing Sherrin Creek and Wishbone locations in Australia.
Phosphate in Queensland ..... and Northern Territory
Phosphate in Queensland ..... and Northern Territory

Sherrin Creek Phosphate, NW Queensland
(from Campbell, 1968)

Lab P2O5 Values

Natural Gamma Log
Crandallite Zone (where Ba, Sr, REOs, and U substitute for the Ca)
Phosphate in Queensland ..... and Northern Territory

**Sherrin Creek Drilling Summary - 1968**

<table>
<thead>
<tr>
<th>Hole</th>
<th>Total Depth (ft)</th>
<th>Depth to Top of Zone (ft)</th>
<th>Thickness of Zone</th>
<th>Average % P$_2$O$_5$ of Zone (≥10%)</th>
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</thead>
<tbody>
<tr>
<td>SC 1-68</td>
<td>81</td>
<td>61</td>
<td>8 ft</td>
<td>20.1% 26.1%</td>
</tr>
<tr>
<td>SC 2-68</td>
<td>51</td>
<td>- Lost Hole</td>
<td>-</td>
<td>-</td>
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<tr>
<td>SC 3-68</td>
<td>105</td>
<td>47 (1st Zone) 2 ft</td>
<td>72 (2nd Zone) 5 ft</td>
<td>10.5% 13.7%</td>
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<tr>
<td></td>
<td></td>
<td>85 (3rd Zone) 4 ft</td>
<td></td>
<td>13.0% 16.9%</td>
</tr>
<tr>
<td>SC 4-68</td>
<td>90</td>
<td>50</td>
<td>16 ft</td>
<td>12.6% 16.4%</td>
</tr>
<tr>
<td>SC 5-68</td>
<td>82</td>
<td>59</td>
<td>14 ft</td>
<td>14.8% 19.2%</td>
</tr>
<tr>
<td>SC 8-68</td>
<td>101</td>
<td>59</td>
<td>8 ft</td>
<td>15.5% 20.2%</td>
</tr>
<tr>
<td>SC 17-68</td>
<td>82</td>
<td>33</td>
<td>7 ft</td>
<td>11.1% 14.4%</td>
</tr>
<tr>
<td>SC 18-68</td>
<td>91</td>
<td>74</td>
<td>8 ft</td>
<td>14.1% 18.3%</td>
</tr>
<tr>
<td>SC 19-68</td>
<td>86</td>
<td>74</td>
<td>1 ft</td>
<td>11.4% 14.8%</td>
</tr>
<tr>
<td>SC 20-68</td>
<td>79</td>
<td>59 (1st Zone) 4 ft</td>
<td>68 (2nd Zone) 1 ft</td>
<td>12.8% 16.6%</td>
</tr>
</tbody>
</table>

Note: Subsequent drilling with cased holes by others indicated +30% higher P$_2$O$_5$ values. Why? Drilling P$_2$O$_5$ dust loss and vuggy formation: In-out subsurface air flow as noted by Campbell (1968) captures P$_2$O$_5$ dust.
Sherrin Creek, Qld…. and Alroy Downs, NT Areas

**Sherrin Creek Area**

<table>
<thead>
<tr>
<th>Footage</th>
<th>F</th>
<th>% P2O5</th>
<th>A</th>
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<tr>
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<tr>
<td>53-54</td>
<td>&lt; 1</td>
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<tr>
<td>55</td>
<td>&lt; 1</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>56</td>
<td>&lt; 1</td>
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<tr>
<td>57</td>
<td>&lt; 1</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>58</td>
<td>2</td>
<td>-</td>
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<tr>
<td>59</td>
<td>&lt; 1</td>
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**Alroy Downs Area**

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<td>10.3</td>
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<tr>
<td>80</td>
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Queensland

Northern Territory

27.7%

9.5%
Sherrin Creek, Queensland

After Campbell (1969), p.25 and Plate III
Queensland Potash
Queensland Potash

- Oil & Gas Drilling
- Adavale Basin
- Thick Salt Intervals
- Potash Zones?
- Cross Section Location
Queensland Potash

Cross Section

Shows:
- Thick Salt Zone Indicated
- Top and Bottom of Salt
- Unit can be Mapped
- Possible Potash Zones

From McKillop, et al., 2007
Queensland Potash

Salt Member > 250 Meters Thick, also within 2,500 meters of the Surface

See Core Analysis
Queensland Potash

Core Analyses Showing Some High Potassium Values

Chemical Analyses for Bury No. 1 Cores
(From A.H. White, Poseidon Limited, 11/30/83)

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<th>Core</th>
<th>Depth (ft)</th>
<th>NaCl (%)</th>
<th>Insoluble (%)</th>
<th>Calcium</th>
<th>Magnesium</th>
<th>Sulfate</th>
<th>Potassium</th>
<th>Bromine</th>
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<td>2.4110</td>
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<td>1,253</td>
<td>4,143</td>
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<table>
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<tr>
<th>Core</th>
<th>Depth (ft)</th>
<th>NaCl (%)</th>
<th>Insoluble (%)</th>
<th>Calcium</th>
<th>Magnesium</th>
<th>Sulfate</th>
<th>Potassium</th>
<th>Bromine</th>
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<tbody>
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<td>10</td>
<td>6969</td>
<td>98.3</td>
<td>0.8780</td>
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Core Samples Analyses

Potassium

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<tr>
<th>Depth (ft)</th>
<th>PPM</th>
<th>10 PPM</th>
<th>1,000 PPM</th>
<th>10,000 PPM</th>
<th>100,000 PPM</th>
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<td>2.9270</td>
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<td>0.9680</td>
<td>1.9980</td>
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<td>6.3920</td>
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<td>4.0700</td>
<td>3.2960</td>
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<td>682</td>
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<td>93</td>
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<td>7487 (495m)</td>
<td>96.3</td>
<td>1.7850</td>
<td>2,669</td>
<td>5,183</td>
<td>944</td>
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</table>

High SO₄, Low Br
High SO₄, Low Br
High SO₄, Low Br
High SO₄, Low Br
High SO₄, Low Br

Analyses & Core Depths
From: A.H. White, 11/30/83
Queensland Potash

Possible Downhole Solution Mining

Model of Potash Formation
Scope of Work for Assessment:

- evaluate the available reports on the uranium resources available and the in situ recovery (ISR) methodology under consideration by the Company in the exploration and development activities to date by performing a geological and metallurgical peer review and due diligence on the [REDACTED] Project in South Australia,

- evaluate the professional staff of [REDACTED] the Company and associated hydrogeological consultant,

- review assumptions in the financial model emphasizing capital expenditures and operating costs and the associated impacts, and

- identify associated risks regarding the proposed in situ uranium leaching and recovery process for production of yellowcake and sale on the spot market or other markets,
South Australia Uranium

Previous Work

Lime green radium mineral reported

(From Campbell, 1969)

Hand Augering
Dry Lake Beds

Campbell Prospect

Tenement Location Map
South Australia Uranium

Pre-Visit Model of Uranium Occurrence

Classical Roll-Front Uranium Model for Exploration
South Australia Uranium

Rotary mud drill hole MRM 167 drilled at the eastern extremity of the deposit

Radiometrically anomalous clay-altered granite ~12m below the Eocene unconformity.

During I2M Visit: Identified Potential Role of Unconformity Uranium Model

Eocene unconformity, ~51m

Radiometrically anomalous clay-altered granite, ~63m
Summary and Conclusions of I2M Report:

- Based on the grid drilling conducted to date, the Company has discovered two areas with significant uranium mineralization (i.e., the areas).

- Upon assessing the resource characterization from the logs, cores and geological review, it appears that the available mineralization of the discovery is less than that indicated by the Company. This would result in substantially less in situ recovery from certain areas of the deposit thus reducing the ultimate recovery of grade uranium (U₃O₈).

- The existing drill holes are insufficient in number and spacing to identify the interior characteristics of the uranium mineralization.

- The underlying granite and its uranium content needs to be better understood as it could contain potentially economic quantities of uranium.

- More core drilling should occur to better understand the geology of the deposit, the amount of available uranium in the sediments and in the underlying granite basement.

- In situ processing of the uranium would be unusually difficult to control under the high-saline environment present in the subsurface.

- The risk of economic recovery from in situ leaching and ion exchange is high due to acid soluble calcium prevalent in the subsurface system, high chloride levels and unknown distribution of the uranium mineralization.

- A move to an open-pit method of mining the deposit should be reviewed, but this method introduces the necessity of re-initiating further permitting, drilling and coring thus delaying production dates.
Disequilibrium Studies:

“MRM 881 reported a peak grade of 5.04% $\text{eU}_3\text{O}_8$ (50,362 ppm) within a broader high grade intercept (cut-off 100 ppm $\text{eU}_3\text{O}_8$):

- **PFN (Prompt Fission Neutron) Logging**
  - Direct measure of $^{235}\text{U}$
  - Provides spontaneous measure of disequilibrium
  - Expensive, complex, high maintenance system
  - Requires specialist radiation licensing
  - Limited availability
  - Very slow logging speed (~0.5 m/min)

- **Total Gamma Logging**
  - Indirect measurement of uranium ($^{214}\text{Bi}$ and $^{214}\text{Pb}$)
  - Cheap and reliable equipment
  - Measures all radio nucleotides (Sum of K+Th+U...)

- **Spectral Gamma Logging**
  - Measures the energy spectrum of gamma radiation and can discern between different radio nucleotides such as uranium ($^{214}\text{Bi}$), thorium ($^{208}\text{Ti}$), K.
  (After Skidmore (2009))
South Australia Uranium

Subsequent Work on the Unconformity-Related Uranium Occurrences
South Australia Uranium

New Model of Uranium in the Subject Area
Vietnam Gold
In Hanoi, preparing for the Vietnamese Lunar New Year celebration – called TET. Government extolling virtues of their accomplishments over the past year… Increased commerce and electricity…
Domal structure and is composed of volcanic rocks surrounded by faulted sedimentary rocks underlain by intrusive bodies of mafic and mafic-intermediate composition intersected by fault systems of NW-SE and conjugant NE-SW strike.
Pre-hip replacement field transportation up and down the mountains

Underground mining by adit of about 200 yards to working mine face adits.

Client-Consultant discussions at mine
Vietnam Gold

Ore Dump

Hanging Wall-Footwall w/ Mineralization

Sampling at the Mining Face

<table>
<thead>
<tr>
<th>Mineralized Zones</th>
<th>Gangue Minerals</th>
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<tbody>
<tr>
<td></td>
<td>Hydrothermal Minerals</td>
</tr>
<tr>
<td>Pyrite</td>
<td>Goethite</td>
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<tr>
<td>Arsenopyrite</td>
<td>Hydrogoethite</td>
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<tr>
<td>Galena</td>
<td>Anglesite</td>
</tr>
<tr>
<td>Sphalerite</td>
<td>Coveline</td>
</tr>
<tr>
<td>Chalcopyrite</td>
<td>Chalcocite</td>
</tr>
<tr>
<td>Native gold</td>
<td>Malachite</td>
</tr>
<tr>
<td>Electrum</td>
<td>Azurite</td>
</tr>
<tr>
<td>Pyrrhotite</td>
<td>Bromite</td>
</tr>
<tr>
<td>Bornite</td>
<td>Svanbergite</td>
</tr>
<tr>
<td>Bronze</td>
<td>Pyromorphite</td>
</tr>
</tbody>
</table>

*Note: Modified from table in Nguyen Duc Lu, No Date, “Brief Outlines on Gold of Vietnam,” 15 p*
Vietnam Gold

New Pit ...safety hazard!

Mineralized Quartz Breccia

Slickensides

Mining Company, Government, and I2M Personnel
Vietnam Gold

Native Gold and Pyrite

Pyrrhotite, Pyrite and Quartz

Chalcopyrite and Covellite

Pyrite, Calcite, and Quartz
Vietnam Gold

Regional Geological Survey of Vietnam

Presentation of Geological Information

Heading to Meetings with Mining Company Personnel
Vietnam Gold

Processing Plant

Primary Crusher, Flotation Cells and Primary Filters

Toward Rice Fields
Vietnam Gold

Final Filtration System – Pond Missing

Breach in Tailings Pond Wall into Local Creek

Sampling Tailings Pond Sediments of Final Filters
## Tailings Geochemistry

### Plant Trench, Tailings Pond and Stream Sediments
Arsenic, Cadmium, Mercury, and Lead

<table>
<thead>
<tr>
<th>Sample ID#</th>
<th>Sample Area</th>
<th>Arsenic (ppm)</th>
<th>Cadmium (ppb)</th>
<th>Mercury (ppb)</th>
<th>Lead (ppm)</th>
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</thead>
<tbody>
<tr>
<td>I2MA-0001</td>
<td>CAO Ram Trench</td>
<td>2,530</td>
<td>620</td>
<td>178</td>
<td>47.0</td>
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<td>I2MA-0002</td>
<td>CAO Ram Trench</td>
<td>2,510</td>
<td>560</td>
<td>182</td>
<td>41.9</td>
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<td>I2MA-0003</td>
<td>CAO Ram Pond</td>
<td>6,250</td>
<td>860</td>
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<td>42.7</td>
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<td>CAO Ram Pond</td>
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<td>870</td>
<td>342</td>
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<td>I2MA-0005</td>
<td>CAO Ram Creek</td>
<td>3,610</td>
<td>660</td>
<td>158</td>
<td>30.9</td>
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<td>I2MA-0006</td>
<td>CAO Ram Creek</td>
<td>3,790</td>
<td>730</td>
<td>177</td>
<td>33.5</td>
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<td>Detection Limit</td>
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<td>0.2</td>
<td>20</td>
<td>5</td>
<td>0.5</td>
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</table>
Vietnam Gold

Sampling Results for Arsenic
Vietnam Gold

Sampling Results for Gold

Vietnam Sampling-2014 - Gold

Tailing Pond Sediments

I2M Field Sampling
Vietnam Gold

Last Evening Dinner Ceremony at the Metropole Hotel

Preparing for the Tet at Hanoi University

Farewell to Vietnam and off to Hong Kong
Texas Uranium
Typical Uranium Deposit in Selected Formations of U.S. Gulf Coast

Significant Differences at Mestena:

1. Classical mineralization also fault-related in part.

2. Re-reduced mineralization by methane or hydrogen sulfide.

3. Uranium occurs at multiple levels

Drill Samples

* in 1977 HGS Text
Texas Uranium
Typical Uranium Deposit in Selected Formations of U.S. Gulf Coast

Geologic Model at Alta Mesa Mine, Texas

Alta Mesa Salt Dome


Downhole Wireline Logging

Yellowcake Production
Our optimistic economic conclusions were qualified as:

1) Assuming yellowcake price does not increase as projected herein

2) Assuming nuclear power plant construction slows or is halted.

3) Assuming development problems do not develop with the ore present in the Mesteña Grande area (to northwest).

4) Assuming a materials shortage does not develop that could delay construction of the new processing plant or compromise the operation of the present plant.

5) Assuming no substantial cost inflation occurs.

6) Assuming a major regulatory issue does not develop relating to an accident, leak, or spill at the existing plant.

Total Production to Date: 4.6 million pounds (U₃O₈)

News: Energy Fuels is acquiring Mestena!
Uranium Elsewhere in Texas
Red flames symbols indicate anomalous uranium in groundwater samples from water wells (see Campbell, et al., 2015 pp. 21-28).
Alaska Uranium and Rare Earths

1st Year Team: Reconnaissance

Field Management Team

2nd Year Team: Geological Mapping and Sampling
Alaska Uranium and Rare Earths

**Alkalinity Ratio vs. SiO₂**

- **Country Rock (with Pluton Unit)**
- **Dike Rock (with Pluton Unit)**
- **Significant Mineralization (U, Th, and REE)**

Possible Geochemical Anomaly:

\[
\frac{Al₂O₃ + CaO + Alkalis^*}{Al₂O₃ + CaO - Alkalis^*}
\]

*When SiO₂ > 50% (Wt.) and K₂O: Na₂O > 1 < 2.5, then 2[Na₂O% w.t.] is substituted for Alkalis.*
Alaska Uranium and Rare Earths

- Led to the area by results of the NURE Program of the late 1970’s
- Field reconnaissance discovered new uranium and rare-earth deposits
- More than $300,000 spent to date but remains to be developed
Alaska Uranium and Rare Earths

**Allanite**  \( \text{Ca(Ce,La,Y,Ca)Al}_2(\text{Fe}^{2+},\text{Fe}^{3+})(\text{SiO}_4)(\text{Si}_2\text{O}_7)\text{O(OH)} \)

- Allanite is a member of the epidote mineral group, where some calcium atoms are replaced by REE, particularly cerium.

- The REE content of allanite is typically about 5 % REO, but can vary widely from 3 to 51 %, depending on the local geological conditions, i.e., faulting, contacts with plutonic bodies, etc.

**Cathodoluminescence Studies**
Alaska Uranium and Rare Earths

- Allanite is most commonly found as an accessory mineral in igneous rocks, but rarely in sufficient concentration to be economically mined.

- Typically these igneous rocks include granites, syenites, diorites, and their associated pegmatites.

- The mineral usually occurs as black to dark brown and brownish-violet tabular grains. It has a conchoidal fracture and is often metamict (i.e., its crystal lattice is disrupted while the mineral grain retains its original morphology) due to radioactive decay of thorium, which can weaken the crystal structure.

- The specific gravity of allanite is 3.4 to 4.2 and its hardness is between 5 to 6.5 Moh’s scale. These characteristics suggest a possibility of making concentrates during processing of ore during mining. However, metamict varieties may weather rapidly.

Thin Section Analysis
Alaska Uranium and Rare Earths

Elemental Scans across Allanite Zones

Titanium

Uranium

Thorium

Elemental Scans across Allanite Zones
Alaska Uranium and Rare Earths

Uranium & Titanium Enrichment at Contact
### Table 1. Rare-earth oxide industry uses and market prices.*

<table>
<thead>
<tr>
<th>Metal Oxide</th>
<th>Principal Uses</th>
<th>Price US$/kg</th>
<th>Conversion: 2.2 kg to U.S. $/lb</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lanthanum oxide 99% min</td>
<td>Rechargeable batteries</td>
<td>8.50–9.00</td>
<td>3.86</td>
<td>4.09</td>
</tr>
<tr>
<td>Cerium oxide 99% min</td>
<td>Catalysts, glass, polishing</td>
<td>4.70–4.90</td>
<td>2.14</td>
<td>2.23</td>
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<tr>
<td>Praseodymium oxide 99% min</td>
<td>Magnets, glasses colorant</td>
<td>31.80–32.70</td>
<td>14.45</td>
<td>14.86</td>
</tr>
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<td>Neodymium oxide 99% min</td>
<td>Magnets, lasers, glass</td>
<td>32.50–33.00</td>
<td>14.77</td>
<td>15.00</td>
</tr>
<tr>
<td>Samarium oxide 99% min</td>
<td>Magnets, lighting, lasers</td>
<td>4.25–4.75</td>
<td>1.93</td>
<td>2.16</td>
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<tr>
<td>Europium oxide 99% min</td>
<td>TV color phosphors: red</td>
<td>470.00–490.00</td>
<td>213.64</td>
<td>222.73</td>
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<td>Terbium oxide 99% min</td>
<td>Phosphors: green magnets</td>
<td>720.00–740.00</td>
<td>327.27</td>
<td>336.36</td>
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<td>Dysprosium oxide 99% min</td>
<td>Magnets: lasers</td>
<td>115.00–120.00</td>
<td>52.27</td>
<td>54.55</td>
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<tr>
<td>Gadolinium oxide 99% min</td>
<td>Magnets, superconductors</td>
<td>10.00–10.50</td>
<td>4.55</td>
<td>4.77</td>
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<tr>
<td>Yttrium oxide 99.99% min</td>
<td>Phosphors, ceramics, lasers</td>
<td>15.90–16.40</td>
<td>7.23</td>
<td>7.45</td>
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<tr>
<td>Lutetium oxide 99.99% min</td>
<td>Ceramics, glass, phosphors and lasers</td>
<td>Up to 2,000/kg</td>
<td>454.55</td>
<td>909.09</td>
</tr>
<tr>
<td>Thulium oxide 99.99% min</td>
<td>Superconductors, ceramic magnets, lasers, x-ray devices</td>
<td>Up to 3,000/kg</td>
<td>681.82</td>
<td>1363.64</td>
</tr>
</tbody>
</table>

*Source: Substantially modified from MetalPrices.com, October 2008.

**Note:**
- Present >100 to 1,000 ppm in Allanite Samples, with Uranium and Thorium >1,000 ppm.
- Present < 100 ppm
I2M Assessments

Sudan Uranium and Gold

Utah Uranium

Alaska Uranium, Thorium, Rare Earths

Australia Gold and Other Metals

Ohio Phase II Environmental Projects

Australia Potash and Phosphate

Texas Uranium

Nevada Base Metals and Geothermal Energy

For additional information on associated mineral commodities and environmental issues, see the I2M Web Portal. Use Search Line.