Conflict Minerals and Tantalum

Dr. Iddo Wernick
Program for the Human Environment
The Rockefeller University
New York, NY USA
Outline

• Conflict Minerals
  • Minerals and Conflict
  • Update on Dodd Frank Section 1502
  • Material flows of 3TG

• Tantalum material flows
  • Properties
  • Markets
  • Sources
  • Closing the loop
Minerals and Conflict

….Whenever there are in any country uncultivated lands and unemployed poor, it is clear that the laws of property have been so far extended as to violate natural right. The earth is given as a common stock for man to labor and live on…

Thomas Jefferson (in a letter to James Madison), 1785
Minerals and Conflict

• Dodd Frank 1502 has succeeded at reducing the money from 3TG supporting conflict in the Congo 多德-弗蘭克法案1502成功地減少剛果衝突礦產的財務支援

• Has effectively created a price differential between certified and non-certified mineral sources 有效地形成了認證和非認證礦產的價格差異

• International coordination to monitor refineries remains partial 監測冶煉廠的國際合作仍受侷限

• EU regulations recently passed 歐盟法規最近已通過

• Political situation in Congo remains dynamic 剛果的政治局勢仍然變動中

enough - http://www.enoughproject.org/
Update on Dodd Frank

• “…..dismantle the Dodd-Frank Act and replace it with new policies to encourage economic growth and job creation.” - www.greatagain.gov

• In 2016 Financial Services Committee chairman Jeb Hensarling (R–Texas) introduced legislation that calls for a repeal of section 1502

• D.C. Circuit already shot down section 1502 labeling requirement on the unlikely tenet of corporate free speech

• Bargaining chip in broader dialogue on the future of the Act.

• Publicly traded companies have now been complying for two reporting years.

• Leading companies have already indicated that they will continue
Minerals and Conflict Certification: A gold mine for consultants
Material flows of 3TG
Material flows of 3TG Minerals

Common Features

• Used in relatively small amounts 使用量相對少
  • World mine production measured in 1,000s of tons not 1,000,000s 年產量為千噸，而非萬噸
  • For 2015: Tin 294 kT; Tantalum 1.2 kT; Tungsten 87 kT; Gold 3kT

• Many dispersive uses 用途分散
  • Electronics – Sn, Ta, Au
  • Cutting tools – W

• Desirable specific physical properties 具有理想的物理性質
  • High melting point 高熔點
  • Electric/thermal conductivity 電/熱導率

Source: USGS 2016
Tantalum
Tantalum – Properties

• Superior thermal and electrical properties 卓越的熱性能和電氣性能
• Porosity 孔隙率
• Hard 堅硬
• Easily fabricated 易製造
• Ductile 易延展
• Resistant to acidic corrosion 耐酸性腐蝕

High capacitance per volume and weight 電容量大

Fig. 2. This .. solid-tantalum capacitor.....6.8 µf. at 50 volts ……

Picture: Modern Capacitors May 1963 Electronics World
Tantalum – Properties

Tantalum SMD Capacitor

Flame retardant epoxy resin
Sintered compact of tantalum
Metal terminal Ni, Fe, or Cu

Katano 2014
‘…uses are specialized; substituting an alternative can lead to reduced performance and increased cost….’ Nassar et al. 2015
Figure 16 - Tantalum capacitor consumption estimate ('000'000 units)
Tantalum - Sources

Figure 8 - Tantalum raw materials (mt Ta₂O₅ contained)
Tantalum - Sources

Figure 2. Annual mine production of tantalum contained in concentrates by country and events that affected mine production, 2000–2014.

Tantalum – Sources

Niobium 鈮

Ta and Nb always found together in Nature- many shared physical and Chemical properties 鉭和鈮有許多共同的物理和化學性質，總是在自然界中共同存在

The large Mibra (Volta Grande) open-pit pegmatite mine operated by Companhia Industrial Fluminense’s in Brazil (Itamar Resende). (Image from Tantalum-Niobium International Study Center).

Cross section of winding from a superconductive magnet with NbTi multifilaments embedded in a Cu core.

http://mriquestions.com/superconductive-design.html

United States Geological Survey, 2014
Tantalum - Closing the Loop

Tantalum and Niobium in 29 Cells Phones

Source: Christian et al. 2012
Tantalum – Closing the Loop
Hydrometallurgy

(a) Flowchart

- Ta capacitor scrap
- Oxidation → CO₂, H₂O etc.
- TaO₂ + Ta, SiO₂, MO₂
- Magnetic separation → Fe, Ni (from terminal)
- Water
- Sieving / Flushing → Waste solution
- SiO₂ etc. (from epoxy resin)
- TaO₂ + Ta, MO₂
- Pulverizing / Sieving → MO₂
- TaO₂ + Ta, MO₂
- HNO₃ aq.
- Leaching → Waste solution
- TaO₂ + Ta
- Mg
- Reduction → Ta, MgO, Mg
- Acid
- Leaching → Waste solution
- Ta

(b) Tantalum capacitor scraps

(c) After oxidation

(d) After magnetic separation

(e) After sieving

(f) After leaching

(g) After reduction

Source: Matsuoka et al 2014
Tantalum – Closing the Loop
Pyrometallurgy 乾式冶煉法

Figure 2. View of two phases in the Cu-Fe-C system at 1250 °C

Table 1. Material distribution by phase, with the input amount of tantalum as a parameter

<table>
<thead>
<tr>
<th>Ta input amount (g)</th>
<th>Iron-rich phase</th>
<th>Copper-rich phase</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Ta (wt %)</td>
<td>Cu (wt %)</td>
</tr>
<tr>
<td>0.05</td>
<td>0.33</td>
<td>4.58</td>
</tr>
<tr>
<td>0.10</td>
<td>0.49</td>
<td>4.86</td>
</tr>
<tr>
<td>0.20</td>
<td>1.01</td>
<td>3.81</td>
</tr>
</tbody>
</table>

Source: Kikuchi et al 2014
Average Amount of Elements Found in 29 Cell Phones

Source: Christian et al. 2012
Conclusions

• 3TG monitoring efforts successful with sizable gaps in coverage. 3TG的監測成功，涵蓋面的範圍卻有差距

• Alternative sources (i.e., Tin slag heaps in Australia and Brazil) could become economically attractive for Ta production 替代來源（即澳大利亞和巴西的錫渣堆）可能對鉭生產具有經濟吸引力

• Collection costs and labor costs for large scale Tantalum recovery considerable 大規模收集成本和勞動力成本相當可觀
Thank you for your attention

Thanks to my colleagues Jesse Ausubel and Alan Curry

Program for the Human Environment
The Rockefeller University
phe.rockefeller.edu
References

• USGS 2015, Shift in Global Tantalum Mine Production 2000–2014


• USGS 2016 Mineral Commodity Summary