



Mercury use in Artisanal and Small-scale Mining, existing solutions and international experiences in reduction efforts

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Indonesia, 2008, K. Telmer

Outline

- Perspectives / Background
- Case Studies
- Recommended Actions
 - Local
 - Regional
 - Global

Serra Pelada (The Naked Hill), Brazil Ground Zero, 1979

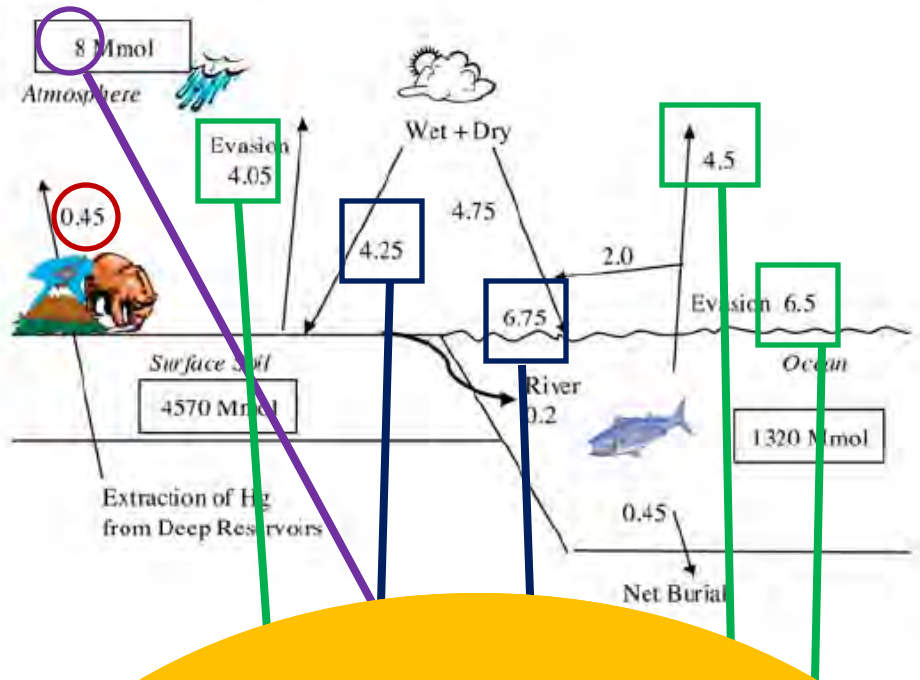




Misperceptions!

Mercury: Pre and Post Industrial Mercury Fluxes and Reservoirs

1 Mmol Hg = 200 tonnes



**Mercury Used:
5 Mmol (1000 tonnes)/yr
for 1000 years
= 5000 Mt (1,000,000 tonnes)**
(Hylander et al., 2006)

100 years of Polar Bears

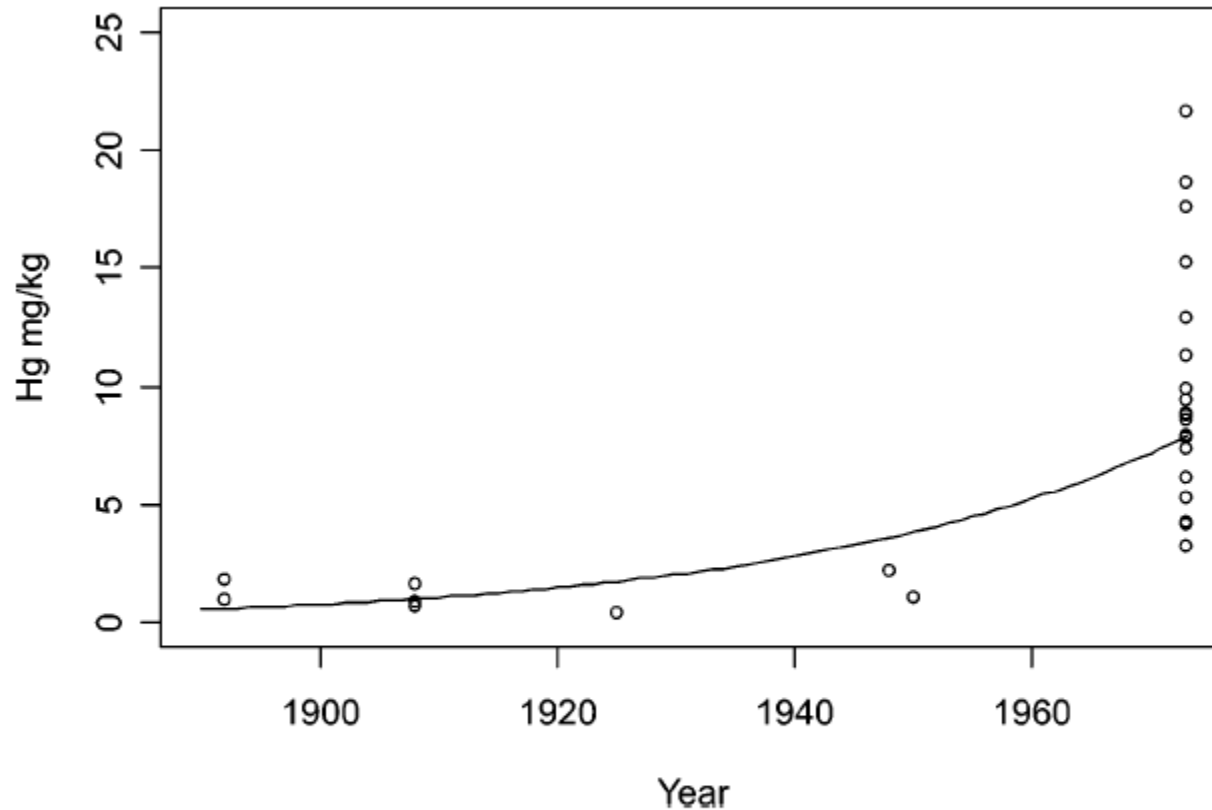


FIGURE 1. Mercury in East Greenland polar bear hair ($n = 27$) between 1892 and 1973 showing a significant ($p < 0.0001$) increasing trend of ca. 3.1%/year (slope = 0.031).

Dietz et al., 2006

Human Health

- Reductions in intelligence
 - 316,500 and 637,200 American children each year
 - \$8.7 billion in lost earnings annually
 - Mount Sinai Center for Children's Health and the Environment
- Decreased number of great ideas
- Decreased Innovation
- ASGM Gold Mining Communities (50 million people) are far worse

Background

- ASGM = Artisanal and Small Scale Gold Mining
- LSGM = Large Scale Gold Mining
- The breadth of society that interacts with Artisanal and Small Scale Gold Mining (ASGM) is much broader than is generally recognized
- Existing gold (135,000 tonnes) is minimally 5% ASGM in origin (about 7000 tonnes)
- Current ASGM production is around 12% - larger than any single producer
- Risk (reputational and operational) for LSGM is increasing due to ASGM
- Gold is getting “dirtier”
 - AP Congolese Child Labour Gold Goes to Swiss Banks:
 - <http://www.guardian.co.uk/worldlatest/story/0,-7714811,00.html>
 - Don't tarnish the Oscars with dirty gold
 - http://www.earthworksaction.org/PR_HarryWinston.cfm
 - But almost all gold remains in circulation...
- In February the world agreed to develop a global mercury treaty - UNEP

Perspective

- There is no single technological “**silver bullet**” to move to a mercury free system

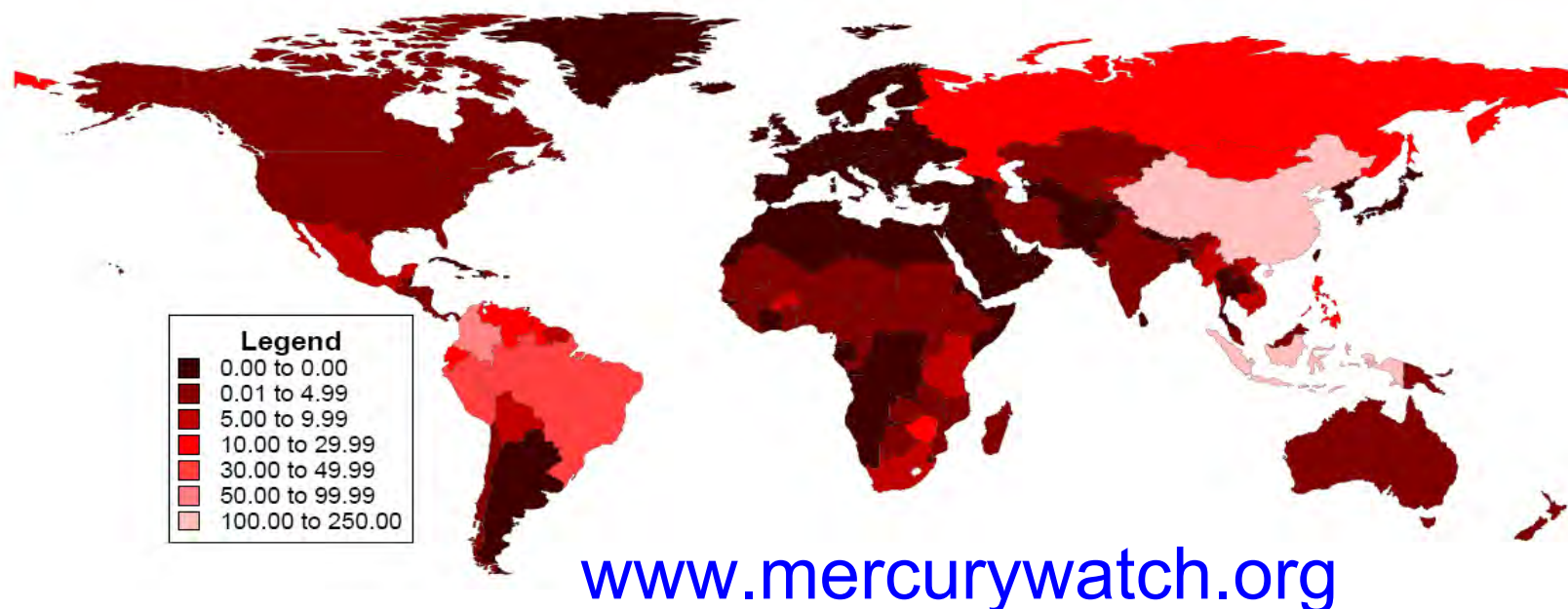
Purpose

- To recast ASGM in a different light,
- dispel myths,
- discuss what can be done to accelerate its transition into a low mercury emission industry
- Into a viable and economically sustainable activity that fits into formal economies and societies
- To provide solutions that are ultimately not donor dependant

Current Estimate and Distribution

- Vast decentralized source – 70 countries (76 probable).
- 400 tonnes/a volatilized to the atmosphere
- 600 tonnes discharged into soils, rivers and lakes
- 1/3 anthropogenic releases, 2nd only to coal burning
- Sources of Information: More than 100 documents + other sources

ASM Mercury Consumption - WORLD



Telmer and Veiga, 2008

Scale and Economy of ASGM

- 330 tonnes of gold from 70 countries
- 9.6 billion USD at 900\$/ozt
- 10 million miners (3 million women and children)
- \$960/miner - unevenly distributed
- Secondary economy, perhaps 50 million people at 50 billion USD/a
- Roughly 2 times the population of Canada at a GDP PPP 40 times lower
- Canada is a good reference because it is perhaps most involved in the gold industry on a per capita basis

Consumption/Emission Intensity ASGM vs LSGM

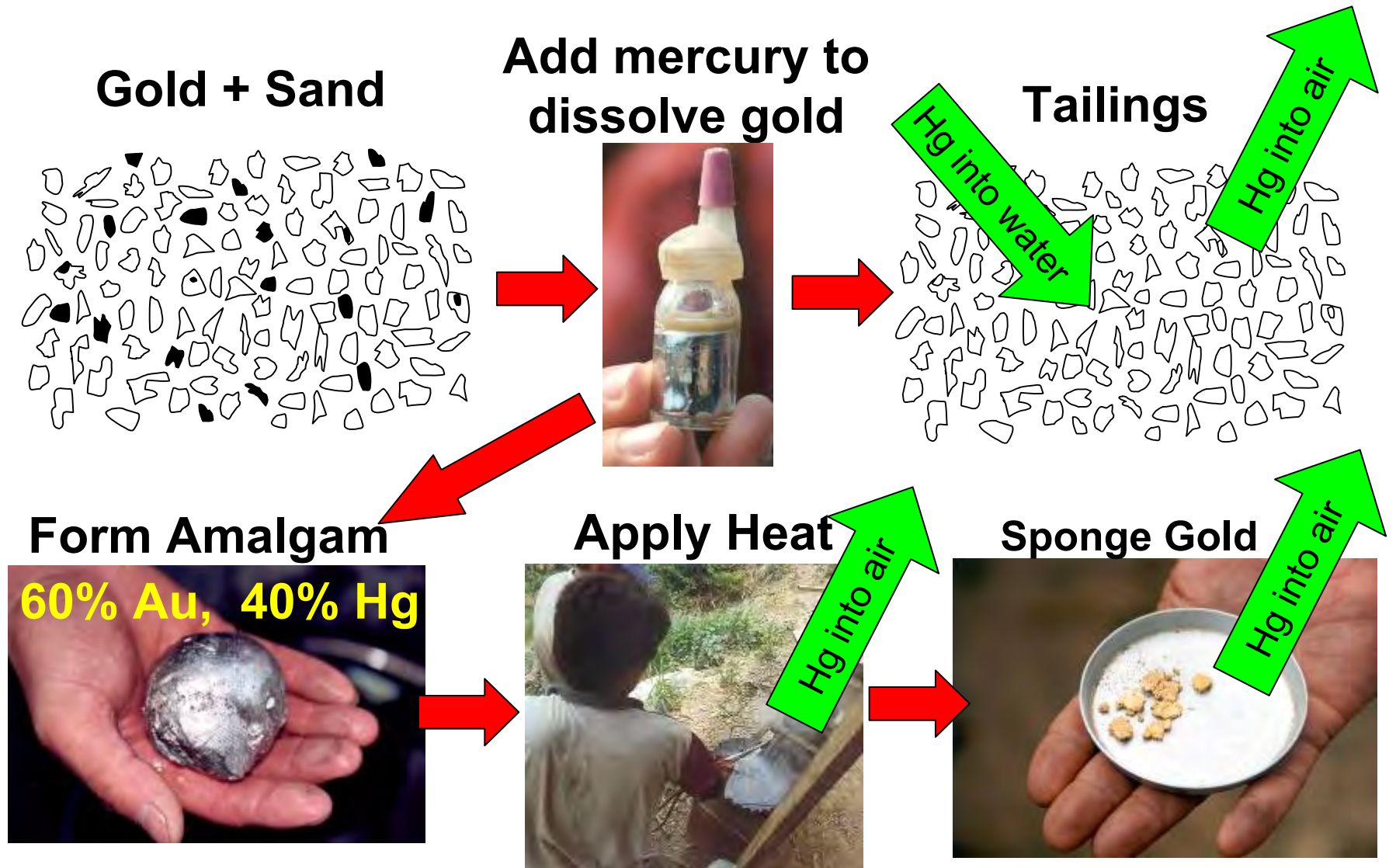
ASGM:

- More energy efficient (joules/unit gold)
- Releases less greenhouse gasses (CO₂e/unit gold)
- Produces less waste rock and tailings per unit gold
- Releases 5 times more mercury in total
- Releases 40 times more mercury per unit of gold produced
- Those who use CN use about twice as much per unit of gold produced
- Do not practice waste management

Remaining ASGM Gold Resources

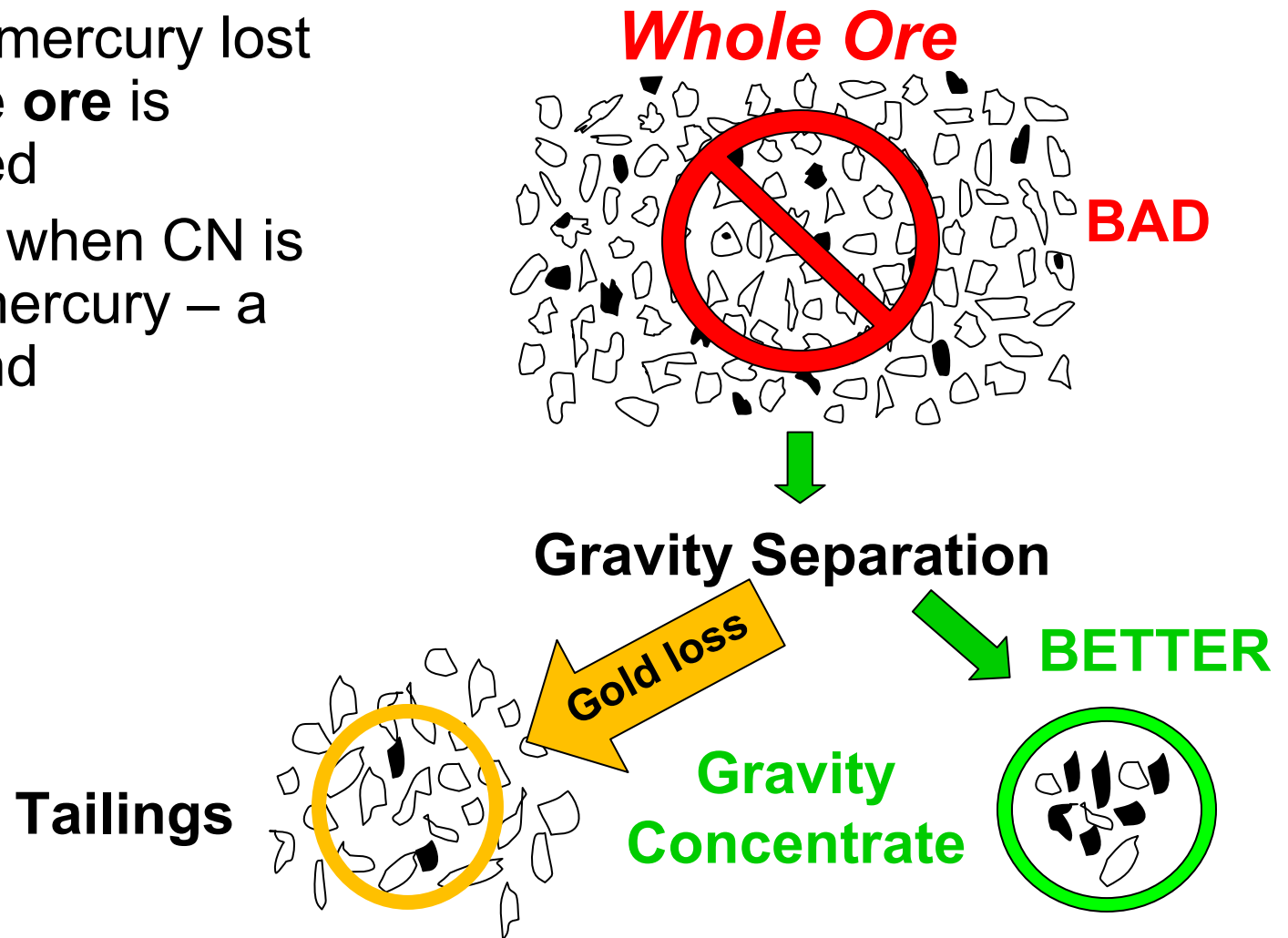
- LSGM resource is 50,000 tonnes of gold (USGS, 2007)
- No equivalent estimate of the ASGM resource
- At 12% of world production, the ASM resource is minimally around **6000 tonnes gold**.
- Would last for **18 years** and would use 18,000 tonnes of mercury.
- True ASGM resource may be significantly larger
 - Traditional estimation methods are inappropriate
- A better estimate is possible using geological evidence and grade and depth distribution models.

How is Mercury Used and Lost?



Mercury Losses Vary With Style of Operation

- Much more mercury lost when **whole ore** is amalgamated
- Even worse when CN is used after mercury – a growing trend



Why is Mercury Used?

- Very easy
- Very independent – 1 person can do it
- Highly effective under field conditions
- Accessible
- Cheap:
 - Jan 22, 2008, mercury US\$0.017/g;
gold US\$28/g
 - **1:1650**
 - (local prices are different)
 - Worst prices 1:125 – still cheap
- Facilitates precise transactions
- Produces quick capital (1 day)
- Divides profits
- Miners are not aware of the risks
- No choice



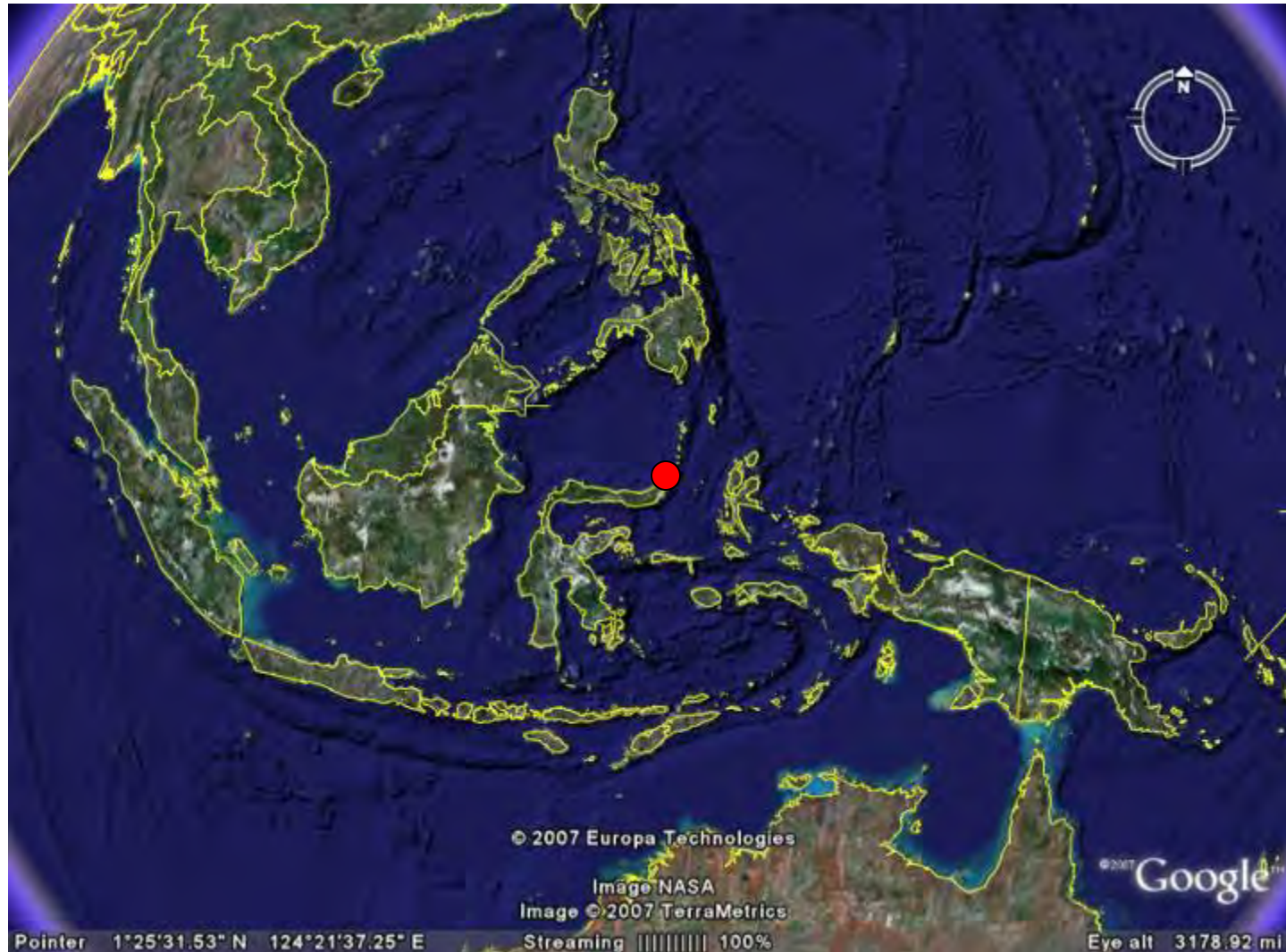
K. Telmer, Tapajos Basin, 1996

**Brazilian miner with
Tremors, 1996**

Three Case Studies, Different Mercury Scenarios

- Primary Mining and Whole Ore Amalgamation in Sulawesi, Indonesia
 - (Hg:Au 20:1 or worse)
- Alluvial Mining and Gravity Concentrate Amalgamation in Kalimantan, Indonesia
 - (Hg:Au = 1.3:1)
- Grasberg Tailings
 - (Hg:Au = 0)

Case 1: Primary Ore and **Whole Ore Amalgamation**, Sulawesi, Indonesia



Case 1: ASM in Colluvial and Primary Ores and **Whole Ore Amalgamation**, Sulawesi, Indonesia



Hand Dug Underground Shafts



Very
Dangerous,
Very far from
Health and
Safety
Compliance



Ore





Crushing





Milling



Preparing to Amalgamate



750 Grams of Mercury



Amalgamating the Whole Ore



Dividing Profits:

Labourer gets to keep whatever gold he can amalgamate as payment for milling the ore. He buys mercury from the miller. This system protects the miller as he pays less for labour on poor ores.

Creating a Slurry and Amalgamating the Whole Ore



Extracting the Slurry and Amalgam



Producing the Amalgam



Amalgam



Amalgam Burning



Amalgam burning



Mecury loss from burning 1 unit Hg, for 1 unit Au

Capturing the Mercury Rich Slurry



- 60-70% of gold remains in slurry
- 20 to 50g mercury per gram of gold is lost to the slurry (A 50:1 ratio!)

As high as 20:1 or 50:1

Mercury Rich Slurry Goes to Cyanidation Process



CN-Hg Rich Tailings



Cyanide Use After Mercury



Gold adsorbed on carbon is recovered by burning, mercury emitted to atmosphere



- Adsorbed gold and lots of adsorbed mercury!
- Carbon is burnt releasing mercury and leaving the gold as a residual ash
- The ash is amalgamated again with mercury
- So in the end, even with this method of using CN, the minimum Hg emission is Hg: Au 1:1
- Need to learn “elution” to recover gold and carbon and save money

Cyano-Mercury Complexes Released into Environment

Atmospheric Evasion

- Enhanced Transport
- Enhanced Bio-Availability
- Enhance Volatilization



Mercury + Cyanide is a Widespread & Growing Problem

The misuse of mercury and cyanide has been observed in:

- Brazil, China, Ecuador, Indonesia, Peru, Phillipines, Zimbabwe
- Cyanide gets more gold but mercury produces quick cash and divides profits
- Sometimes both are used during transition from mercury to cyanide
- **Reputational risk for LSM is huge.**

Case II: Alluvial Ore in Kalimantan



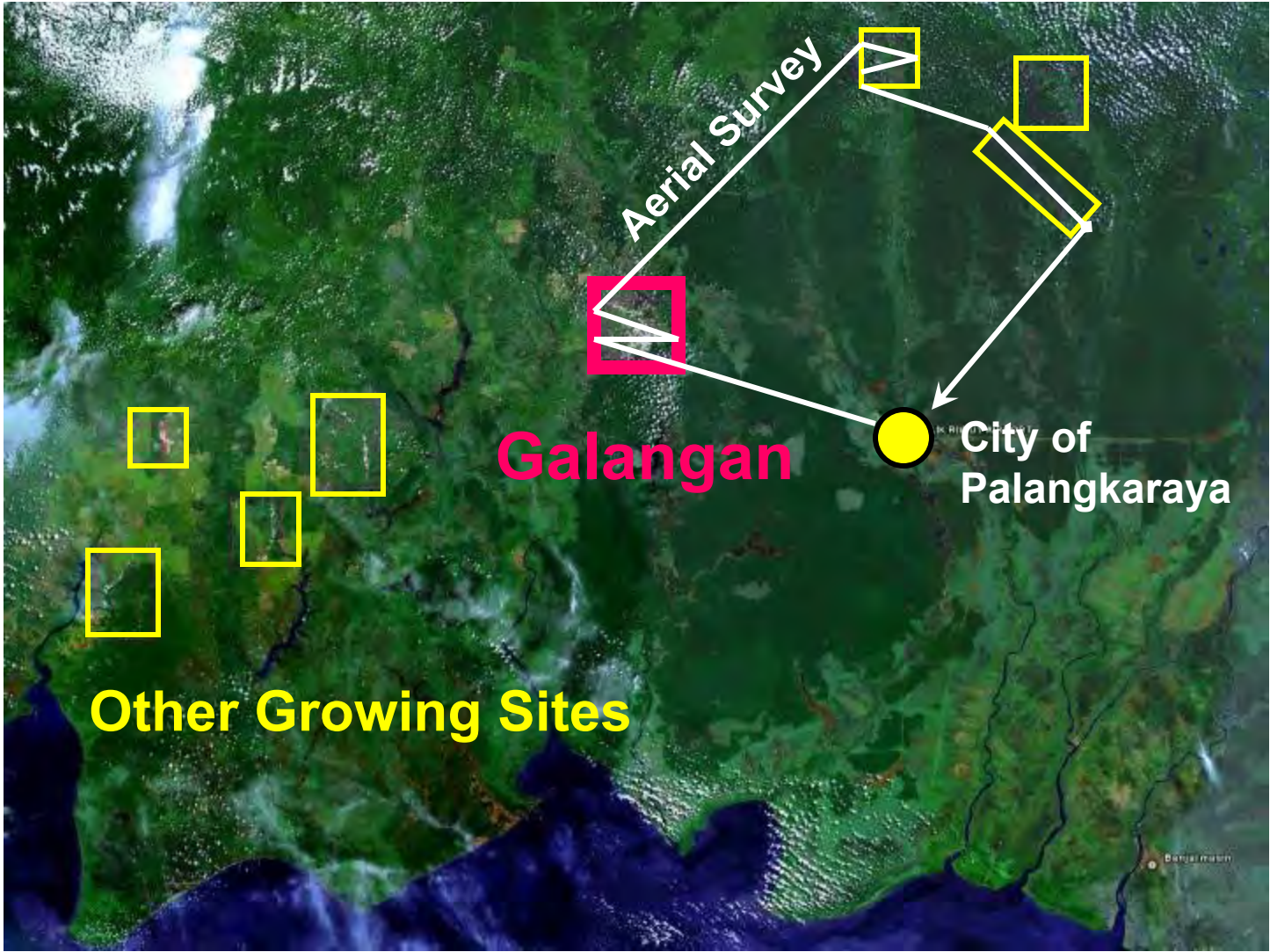
Was habitat for Orangutans



Galangan – 200 km²



One of many growing operations



Aerial View



Mining Pits & Amalgamation Ponds

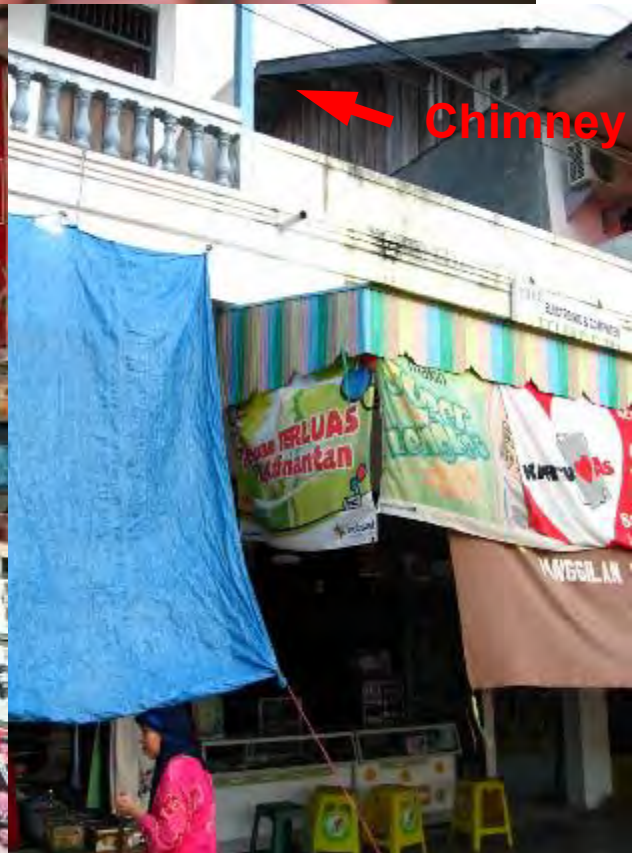


On the ground





Mercury Man



Ignorance



Gold Shop Processing - Cupellation (Fire Assay)







Silver Recovery on Copper



24K
Internationally
Tradable



1990-2008 – 18 years

- Rate of Mining – 8 km²/y
- Gold recovered = 14 t
- Value of gold¹ = \$490 Million US Dollars
- \$35 Million/year for Galangan Area including Dredges
- Directly supports about 40,000 people – 875 \$/year
- Any alternative needs to be this big

1. Determined using gold price variations over time since 1990

Intervention, GMP, 2006

- Where are the largest Hg losses?
- In this case, in the gold shops
- Target gold shops
- Install fume hoods



Intervention - Fume Hood Introduction GMP, 2006



35 US\$
Captures 80-90%
mercury



Reduce mercury consumption by recycling

- Reselling Mercury
- Profitable after capturing only 1 kg Hg
- Prevents Further Imports by 80-90%
- Establishes Relationship with Community
- 35 out of 35 shops installed hood within 6 months
- Still in place in 2009



Sumali Agrawal & Budi Susilorini, GMP, 2007

Fume hood installed by USEPA



Rodolfo Neiva de Souza, GTFM, GMP, Vienna, 2007

Argonne National Lab Program with USEPA



Strips of flat bar steel (40 mm width and 10 mm spacing) are welded to a flat ring.



- Argonne National Laboratory draft report (2008) "Technology Demonstration for Reducing Mercury Emissions From Small-Scale Gold Refining Facilities" prepared for U.S. Environmental Protection Agency

Part II

Specific Recommended Actions

- Local to Regional Actions
- Global Actions

Requirements for Solutions

- Research & Education & Development
 - World Trends – Where and amounts of Mercury
 - Statistics on ASGM
 - Education on Mercury use and gold extraction
 - Knowledge Gaps
 - Reduction Scenarios
 - **Strategies for Engagement**
 - **Technology Innovation**
 - **Governance Innovation**

Some Partners

www.chem.unep.ch/MERCURY/ – United Nations Environment Program. I help them develop materials for their mercury programme which is now strongly focussed on artisanal mining.

www.artisanalmining.org – World Bank Secretariat on Communities and Small Scale Mining. Essentially a network of many players.

www.nrdc.org – Natural Resources Defence Council, an Washington D.C. based NGO with an interest in mercury.

www.gold.org – World Gold Council. Funded by the world's leading gold mining companies with the aim of maximising the demand for Gold.

www.icmm.com – industry consortium of largest mining companies (Teck, Barrick, Rio Tinto...) “International Council on Mining and Metals”.

www.mercurywatch.org – A nacent website that serves data and solutions about artisanal and small scale mining and mercury use for the world.

www.mercury2009.org – Largest scientific meeting on Mercury, happens every 2 or 3 years. Next one is in China 2009.

www.artisanalgold.org – not for profit organisation aimed at creating sustainable livelihoods in gold mining communities.

Approach

- Profit is the most important incentive for creating sustainable change in any ASGM operation.
- Stability and Dignity and Health count but to lesser degree
- Asking miners to change their behaviour in a way that induces a pay cut has been universally unsuccessful
- Interventions where better practices have come along with increased profits have thrived

Reduction Scenarios

- If miners adopted emission control measures (fume hoods and retorts) mercury consumption globally could be reduced by a maximum of 27%
 - This is profitable
- Learning how to re-activate or clean used mercury could reduce mercury consumption by a maximum of 25%
 - This is profitable
- Elimination of whole ore amalgamation could reduce mercury consumption by 45% or more
 - Profitable but much ore complicated
 - More capital, more organisation, more processing sophistication

Sponsor Technology and Business Competitions (Industry + IGO + NGO)

- Sponsored competitions that offer ***cash prizes***
- ASGM X-prize: “***revolution through competition***”
 - <http://www.xprize.org/>
- Education and awareness across up to 70 countries
- Stimulates idea exchange between ASGM communities
 - “south-south” exchange
- Central categories:
 - (1) Waste management;
 - (2) Processing;
 - (3) Product Development / Diversification;
 - (4) Mining

Example: Waste Management and Material Stewardship Competitions

- Fume hoods for gold shops – these are far from perfect
- Retorts for field use – great occupational exposure still occurs to operators
- Mercury Re-activation/Re-Use – greatly decreases mercury consumption
- Tailings management – to reduce mercury loss and river siltation
- Others

Example: Processing Design Competitions

- Elimination of mercury in small scale cyanide processing
- Elimination of whole ore amalgamation
- Tailings management for small scale cyanide
- Processing optimization for small scale cyanide
- Zero-mercury processing

Example: Product Development / Small Business Competitions

- Gold smelting and product development – value added of gold products locally: 24k, 22k, 18k,
– sold directly to local jewellers
- Credit systems – credit increases processing sophistication, efficiency and “greenness”
- Transaction assurance system – assurance without mercury
- Transition to medium scale mining operation – rewarded with IPO on VSX

Support Knowledge Base and Monitoring System for ASGM *(Local Partner + IGO)*

- Support the knowledgebase that is served publically and used:
 - as an open document for discussions with the ASGM community;
 - to encourage input from stakeholders; and
 - to act as an education and awareness vehicle for governments to miners.
 - See a pilot at www.mercurywatch.org
- Facts based communication and education

Monitor Atmospheric Mercury

(Partner + NGO)

- Install mercury vapour analysers as community education and awareness points (not enforcement mechanisms)
- Offers protection for communities and companies – a deterrent to the *abuse* of mercury
- Reduces risk and liability and increases reputation
- Acts as an early warning system
- Creates a line of communication with the informal gold sector
- Establishes baseline conditions for the region and reduces conjecture about emissions

Develop, Diversify, and Remediate Pilot Area (*Partner + Investor + GO*)

- Develop and remediate ASGM area by engaging and employing the local mining community
- Aim for stand alone spin off business
- Start with *one easy site* – “*ground zero*” for ASGM transition
- Begin by performing feasibility study
 - e.g. Central Kalimantan – estimated to contain 5 million ozt of gold; has sophisticated gold merchants ready and willing to upgrade; remediation to orang-utan habitat is possible; safety compliance is not complicated.

Build Centres of Excellence for ASGM

(partner + IGO + NGO + Industry)

- Educate and train experts:
 - product development,
 - clean technology,
 - processing,
 - waste management,
 - environment, health, exploration, economics, safety, policy, conflict resolution, reclamation...
- One on each continent co-located with a large scale mining operation – Asia, South America, Africa
- ~20 graduates/year
- Link them to committed partners in the developing world – e.g. Artisanal Gold Council (Victoria); Global Centre for Artisanal Mining (Vancouver)

Fill Knowledge Gaps

(scientists + partners)

- Sponsor targeted research programs
 - e.g. how long do occupational hazards from emissions persist in gold shops and urban centres
 - e.g. how far does Hg from ASGM go?
- Manages risks of misinformation (gold industry emissions),
- improves reputation,
- Creates information upon which to innovate
- Leverages resources and networks of scientific community to innovate and raise awareness
- Begin at the 9th International Congress on Mercury as a Global Pollutant (ICMGP), China, 2009, the world's premier conference on mercury science

Lobby for Program Based Education and Awareness *(partner + IGO + program + ICMM)*

- The One Laptop per Child program (OLPC, <http://laptop.org/>),
 - sponsored by AMD and Google and many others,
- Offers deep penetration into the rural poor and particularly to children and mothers.
- Raises awareness in both the developing and developed world

Global Approaches

- Mercury Market
- Gold Market

Mercury Market

(IGO + partner + Industry)

- Scarcity will cause mercury conservation in ASGM
- Fume hoods and retorts and re-activation alone can reduce mercury by 50%
- Have been embraced by ASGM communities because they are profitable
- This will be amplified if mercury prices increase
- Easily improved cheaply through technology competitions
- Contributing to causing scarcity provides a publicity opportunity to educate stakeholders about mercury and ASGM and how it can be sustainably reduced
- Underway through Global UNEP Mercury Treaty – needs teeth.

Mercury Market

(IGO + partner +ICMM)

- Not a panacea
 - average mercury usage represents less than 0.2% of revenues from gold
 - If the price were to increase to a seemingly impossible \$3000/kg (currently 20\$/kg) it would only represent 3-10% of gold revenue
- Could cause more smuggling and artisanal production of virgin mercury (capacity is poorly known – good R&D project)

Gold Market

(partner + bank + IGO + Industry)

- Luxury goods market (gold jewellery), and the financial market (bank gold reserves) are becoming more politicized
 - consumer advocacy, investment ethics, sustainability indexing
- Separate ASM gold from LSM gold on world markets
- Of the ~140,000 tonnes of gold in circulation, it can easily be argued that at least 5% or 7000 tonnes of it are ***artisanal gold (AG)***.
- 7000 tonnes of AG gold already exists to be traded
- Begin by allocating and trading some gold as AG at a premium – can be a small amount to begin with
- Letting it trade would avoid over planning and would quickly bring together all stakeholders
- Transparency and re-investment of premium guaranteed through non-profit approach – e.g. Artisanal Gold Council.

Gold Market

(partner + bank + IGO + ICMM)

- Provides a mechanism for communication with the world's ASGM miners and their governments and can be used to coordinate the improvement of practices and governance
 - a market based system to unite the ASGM community, formalize it, and clean up ASGM gold production
- Mission: to support poverty relief and green ASGM and to occur incrementally over time to drive standards towards those of LSM
- Instantly brings global publicity

Gold in Poverty Relief

- Gold represents an excellent method of transferring wealth from rich to poor countries
- Small producers often get 70% or more of international price in remote areas
- This is not true for any other product
- Cell phones and the internet help
- Gold mining is a good development opportunity
- Needs to be brought into formal economy to maximize benefits

Thank you!

Acknowledgements:

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