Export Bans and Reducing Mercury Consumption in Artisanal and Small Scale Gold Mining

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University of Victoria
GEF/UNDP/UNIDO Global Mercury Project

Introductions: Dr. Kevin Telmer

- Ph.D., Geochemistry/Biogeochemistry
- Relevant Experience
  - CIDA: Small Scale Mining and Hg, Brazil
  - IAEA: Hg in tropical environments
  - COMERN: Hg in temperate environments
  - GSC: Metals from smelters
  - NSERC: weathering of sulphides, Hg release
  - GEOMA/FAPESP: Brazilian aquatic systems and Hg
  - **GEF/UNDP/UNIDO: Global Mercury Project**
  - Private Sector:
    - Mine closure plans involving Hg
    - ASM Assessments

Opening Statement

- Export bans can play a key role in reducing mercury consumption in ASM
- Understanding how and why mercury is used in various ASM settings will demonstrate this clearly
- 2 worlds
  - ASM where the price of mercury matters
  - LSM & other industries where the liability of mercury matters
    - Price of mercury is tiny compared to its liability
- Behaviour change = $ in ASM
  - awareness also induces change but less so

Outline

- Mercury and ASM (11 slides)
- Three case studies; three different mercury scenarios (70 slides/pictures)
- The economics of mercury for each case (3 slides)
- Main message to the panel (1 slide)
- The keys to eradicating mercury from ASM (3 slides)
- Concluding Remarks

ASM Overview

- ASM is a global phenomena and its growing due to high gold prices
  - At least 100 million people in over 55 countries depend on ASM
  - ASM produces 20-30% of the world's gold, 500-800 tonnes per annum
  - 10-15 million miners, including at least **4.5 million women** and **1 million children**

Mercury in ASM

- As a consequence of poor practices, 650 to 1000 tonnes of mercury per year are released
- 1/4 to 1/3 of all global anthropogenic releases
- ASM is the single largest intentional-use source of mercury pollution in the world
- Perhaps 100 million people indirectly involved and potentially directly exposed to mercury
- More if the global impact is considered – global contamination of fish

Trade: Mercury is Export and Import

- Mercury is readily available in most countries
- Enters developing countries legally, often for dental use
- The majority ends up being used in ASM

Is It Possible to Limit Supply Locally?

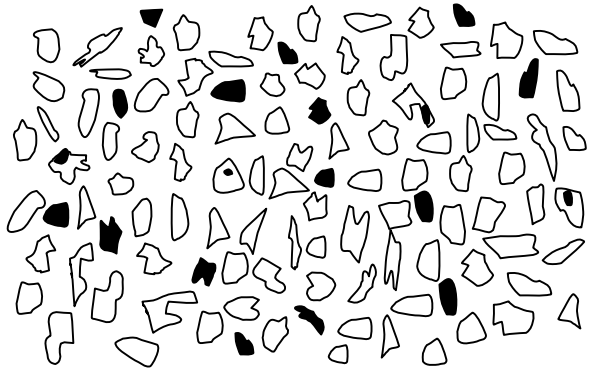
- Almost no success across ASM sector over 30 years
- It should be viewed as any other contraband
- Stringent policy sounds good but drives it underground and out of reach – has occurred due to international interventions
- Regulating imports is more difficult than regulating exports from developed countries
- Export bans from main sources will be easier and more effectively control mercury trade

Environmental Impact Summary

- 300 tonnes of mercury per annum are volatilized directly to the atmosphere
- 700 tonnes are discharged into soils, rivers and lakes.
- Severe occupational hazards – Mercury vapour
- Tens of thousands of polluted sites with far reaching impacts
- Long-term environmental health hazards to populations and ecosystems
- Global food chain contamination
- Global ecosystem damage
- Intense local food chain contamination
- Intense local ecosystem damage
- Neurological damage to people and animals
- Decreased capacity for innovation and prosperity – societal regression

How Is Mercury Used?

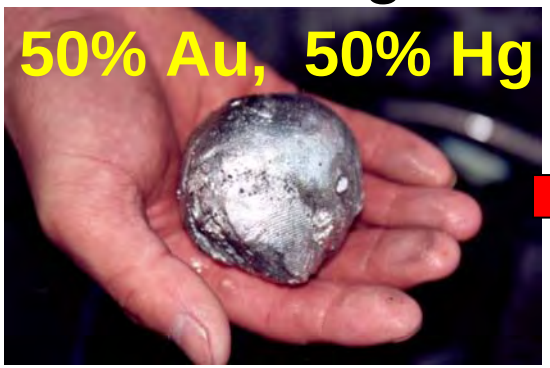
Gold + Sand



Add mercury to dissolve gold

Tailings

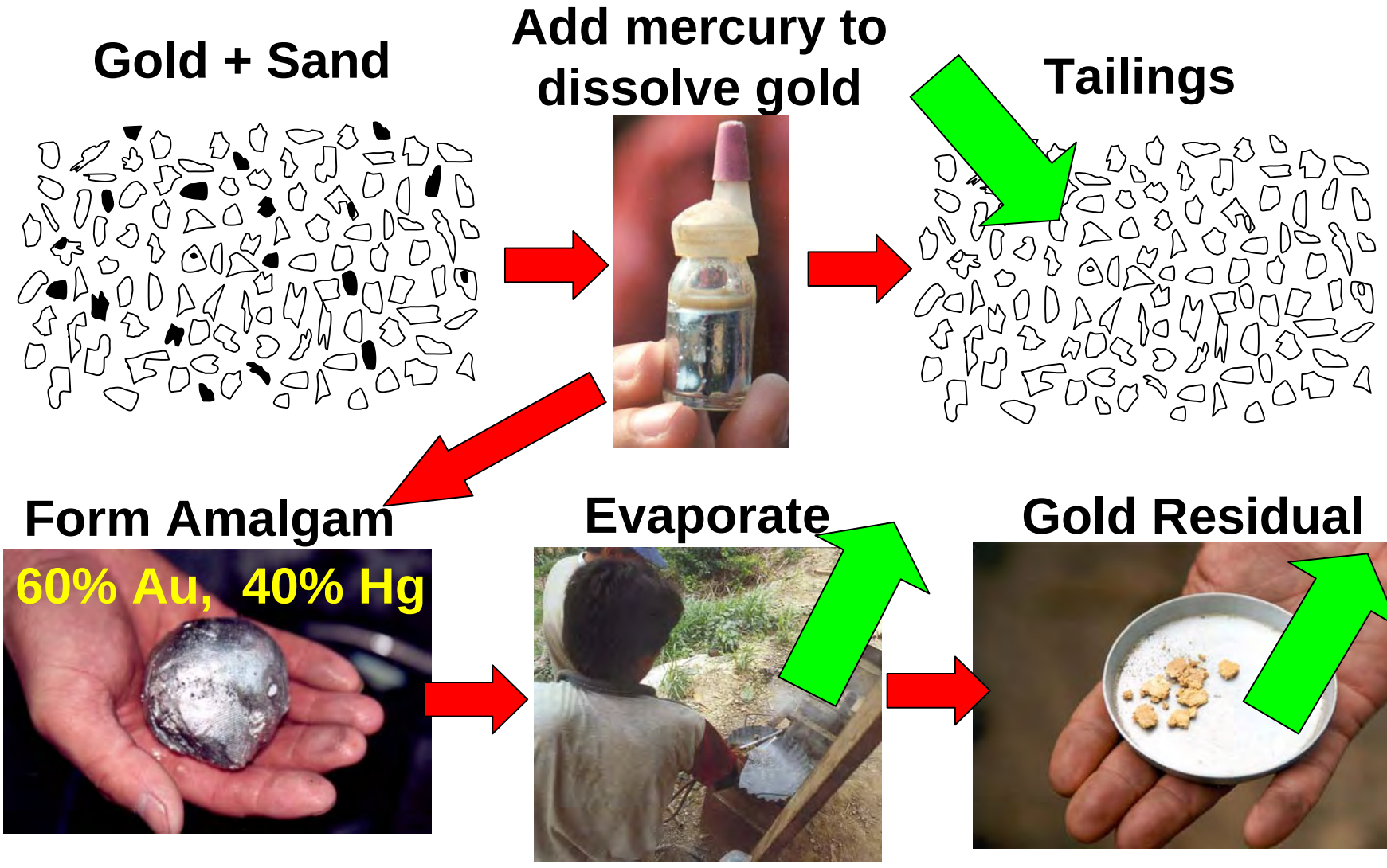
Form Amalgam



Evaporate

Gold Residual

Where Is Mercury Lost?

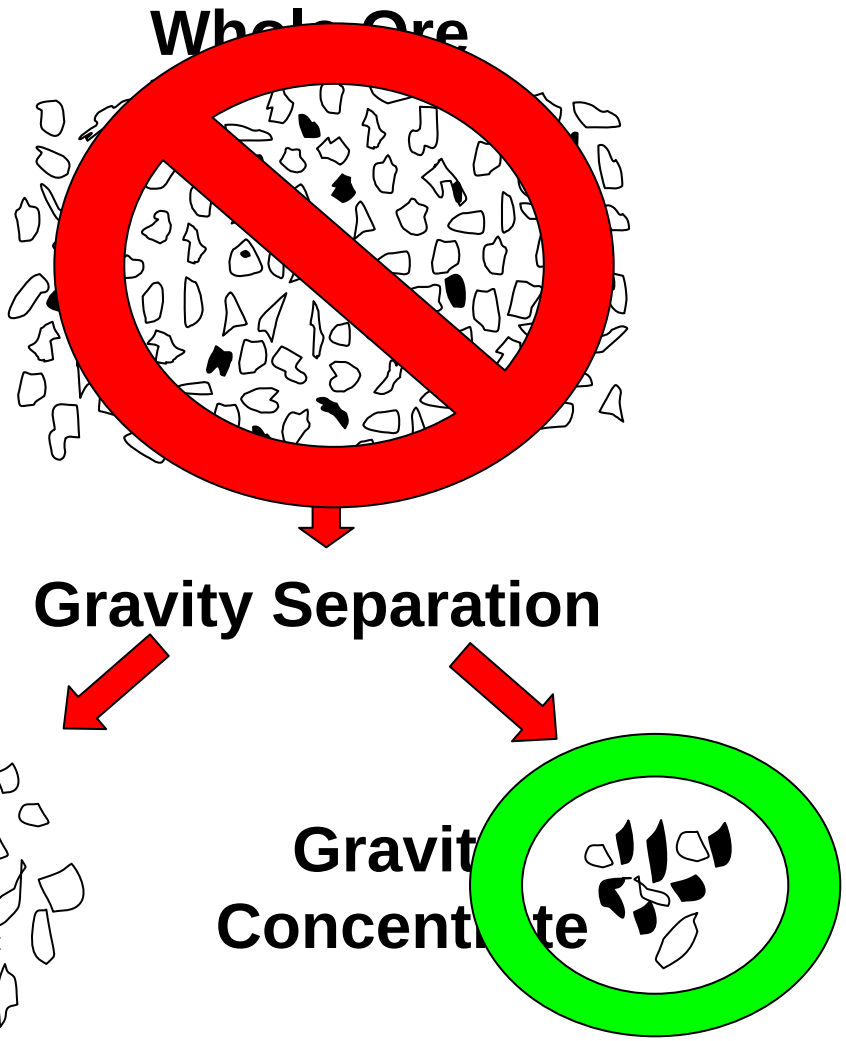


Mercury Losses Vary With Style Of Operation

- Much more mercury lost when **whole ore** is amalgamated

Eliminating whole ore amalgamation can reduce Hg consumption globally by 50% !!

A GMP Focus!



Why is Mercury Used?

- Very easy
- Very independent – 1 person can do it
- Effective
- Accessible
- Cheap:
  - 1g Hg = $0.05;
  - 1g Au = $20;
  - 1:400
  - (local prices are different)
- Miners are not aware of the risks
- No choice

Brazilian miner with Tremors, 1996

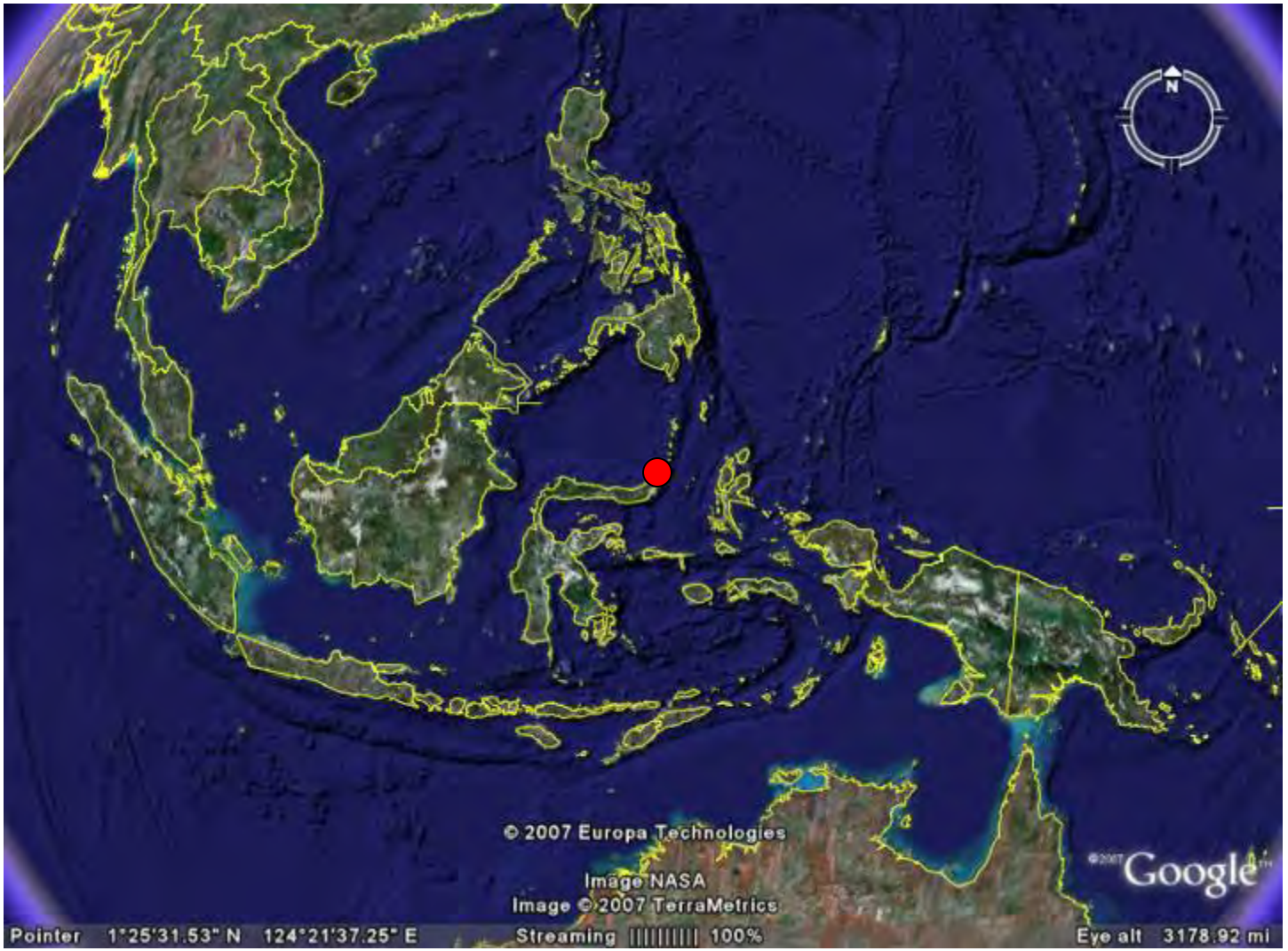
When is Mercury used

- Used when simple gravity methods cannot produce concentrates greater than 10-20% gold
  - Many sluicing operations
- When a supply is available (almost always)
- When capital is needed quickly (subsistence)
  - Sophisticated processing takes too long
  - 1 or 2 months is too long
  - Can you wait more than a month to be paid?
  - Without a credit card?

Three Case Studies, Three Different Mercury Scenarios

- Primary Mining and Whole Ore Amalgamation in Sulawesi, Indonesia
- Alluvial Mining and Gravity Concentrate Amalgamation in Kalimantan, Indonesia
- River Dredging and Gravity Concentrate Amalgamation: Pará, Brazil & Kalimantan, Indonesia

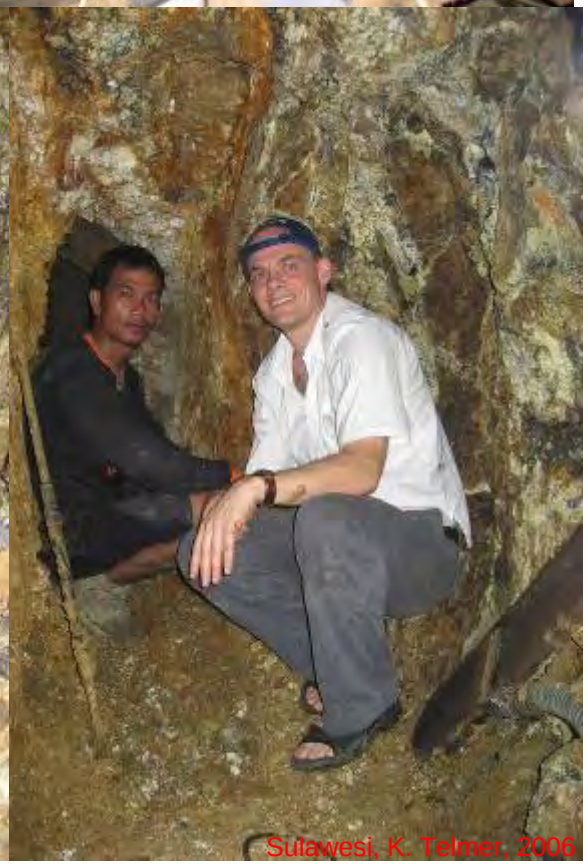
Case 1: ASM in Colluvial and Primary Ores and **Whole Ore Amalgamation**, Sulawesi, Indonesia



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



Sulawesi, K. Telmer, 2006

Ore

Crushing

Sulawesi, K. Telmer, 2006

Milling

Preparing to Amalgamate

750 Grams of Mercury

Amalgamating the Whole Ore

Creating a Slurry and Amalgamating the Whole Ore

Sulawesi, K. Telmer, 2006

Extracting the Slurry and Amalgam

Sulawesi, K. Telmer, 2006

Producing the Amalgam

Sulawesi, K. Telmer, 2006

Amalgam


Kalimantan, K. Telmer, 2006


Kalimantan, K. Telmer, 2006


Kalimantan, K. Telmer, 2006

Amalgam Burning

Amalgam burning

Sulawesi, K. Telmer, 2006


Sulawesi, K. Telmer, 2006

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 50:1

Mercury Rich Slurry Goes to Cyanidation Process

CN tanks and tailings

Cyanide Use After Mercury!

Sulawesi, K. Telmer, 2006

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

Sulawesi, K. Telmer, 2006

Sulawesi, B. Klein, 2006

- adsorbed gold and lots of adsorbed mercury!
- Carbon is burnt releasing mercury and leaving the gold as a residual ash
- Sometimes the ash is amalgamated again with mercury

Slurry Disposal

Sky High in Cyanide and Mercury!

Sulawesi, K. Telmer, 2006

Budi, Susulorini, Sulawesi, K. Telmer, 2006

Cyano-Mercury Complexes Released into Environment

- Enhanced Transport
- Enhanced Bio-Availability

Widespread Phenomena

Misuse of Cyanidation with Amalgamation

Occurring in

- Brazil
- China
- Ecuador
- Indonesia
- Peru
- Philippines
- Zimbabwe

Sulawesi, Indonesia, 2004

GMP goals for this case

- Eliminate Whole Ore Amalgamation
  - Introduce pre-concentration step
- Eliminate Use of Mercury Altogether by replacing it with a viable alternative
  - Small scale CN leaching has potential
  - It is not a global pollutant
  - It is not a persistent pollutant
  - Unlike mercury, It is used sustainably in gold extraction by modern industry

GMP Efforts

Elimination of whole ore amalgamation

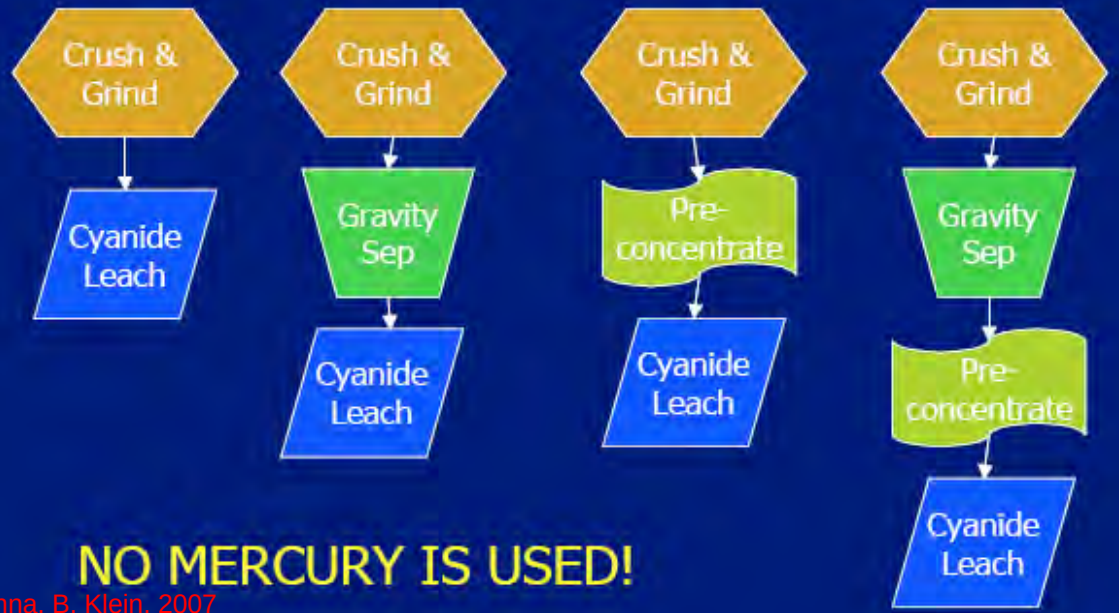
- Pre-amalgamation gravity concentration – R. Baker, 2006

Technological Alternatives

Dr. Bern Klein – Expert Gold Extraction Technologies
Professor of Mineral Processing
University of British Columbia
Department of Mining Engineering

What can be learned from large scale industrial miners that can be applied to small scale mining?

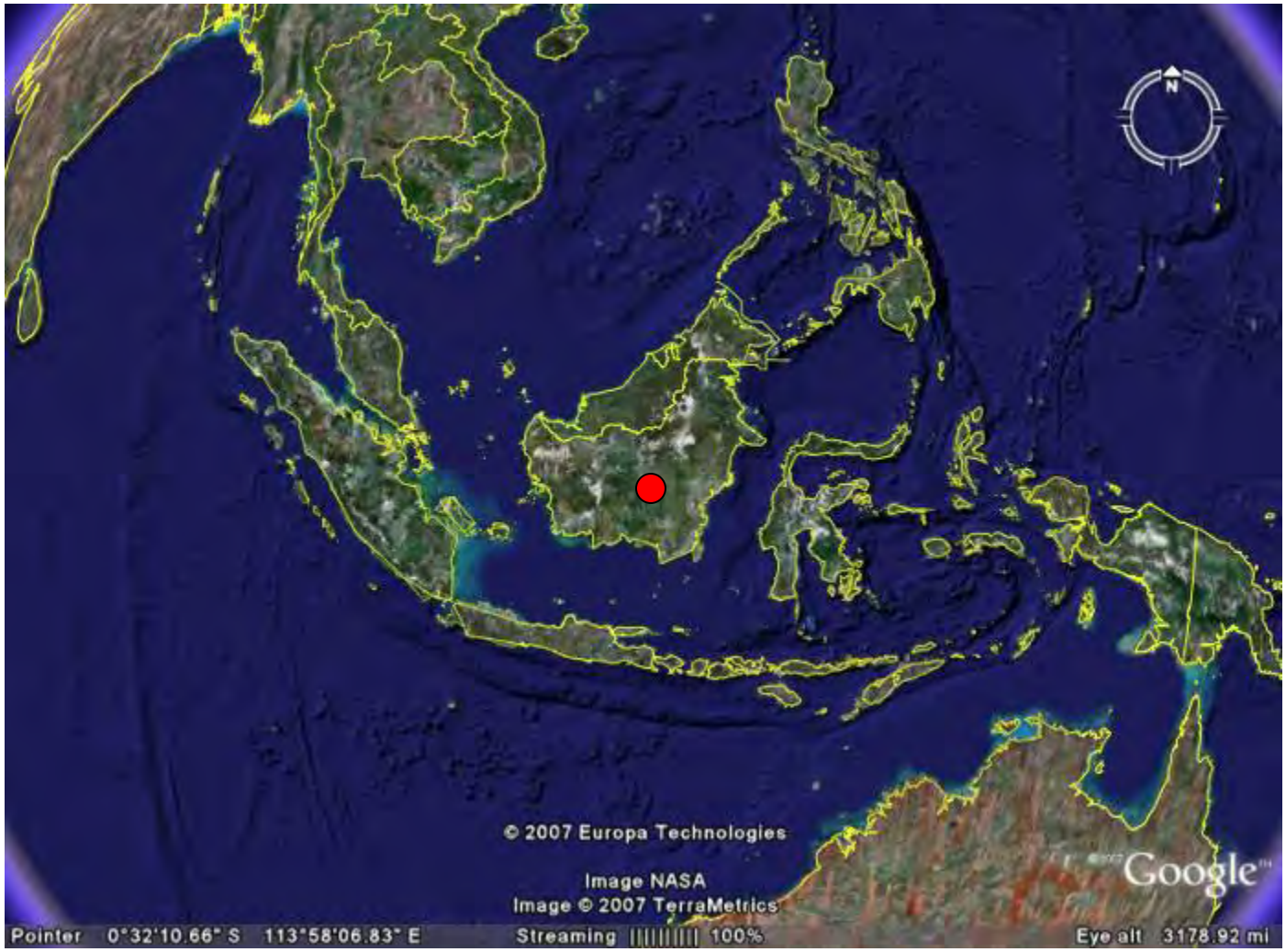
- Simple process with minimum number of steps
- Pre-concentration reduces size/cost of downstream process
- Monitoring and control ensure efficiency and high gold recovery



NO MERCURY IS USED!

Vienna, B. Klein, 2007

Case II: Alluvial Ore in Kalimantan



Was habitat for Orangutans

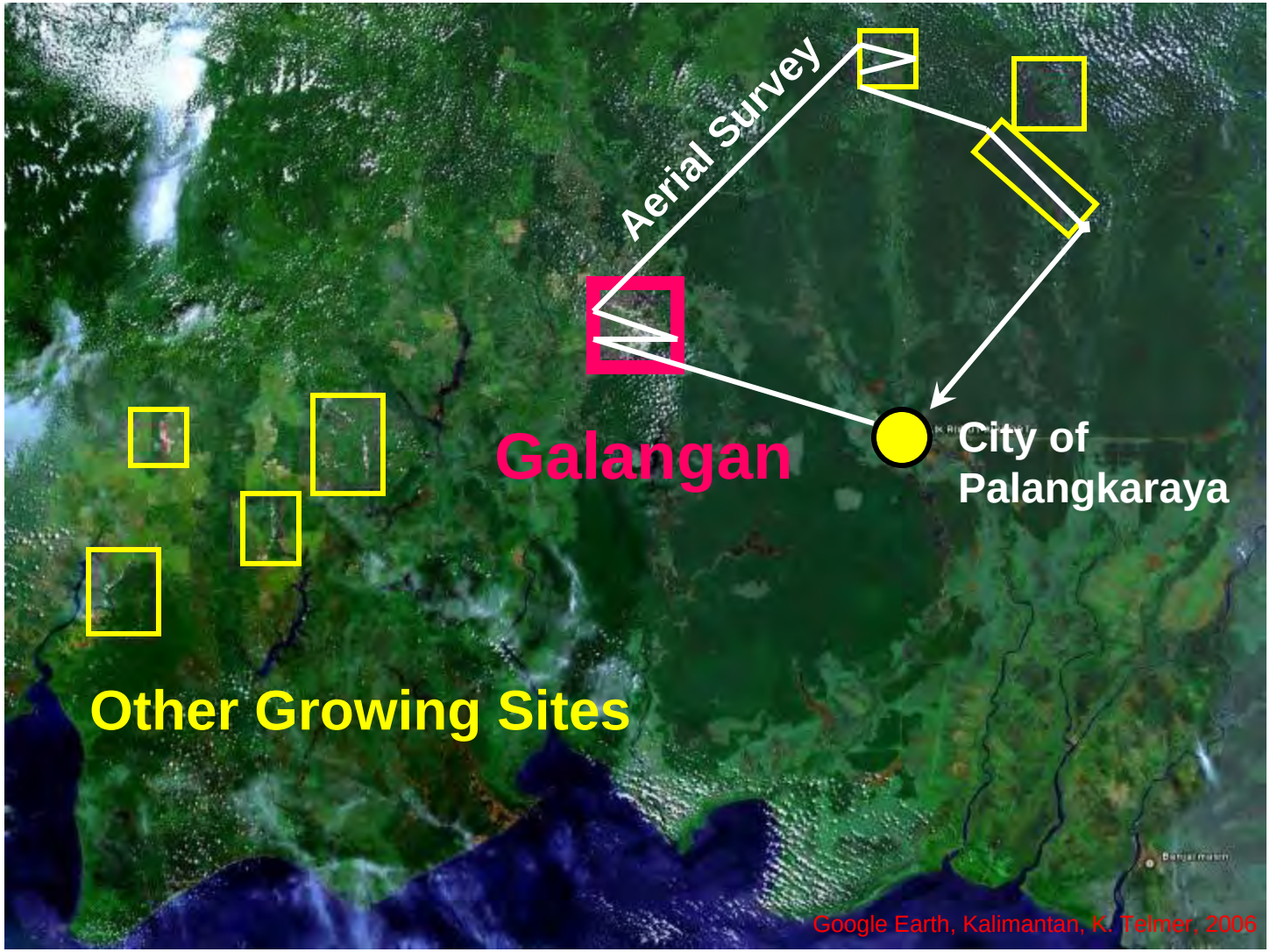
- Only 5000 wild ones left

Kalimantan, K. Telmer, 2006

Galangan – 200 km^2

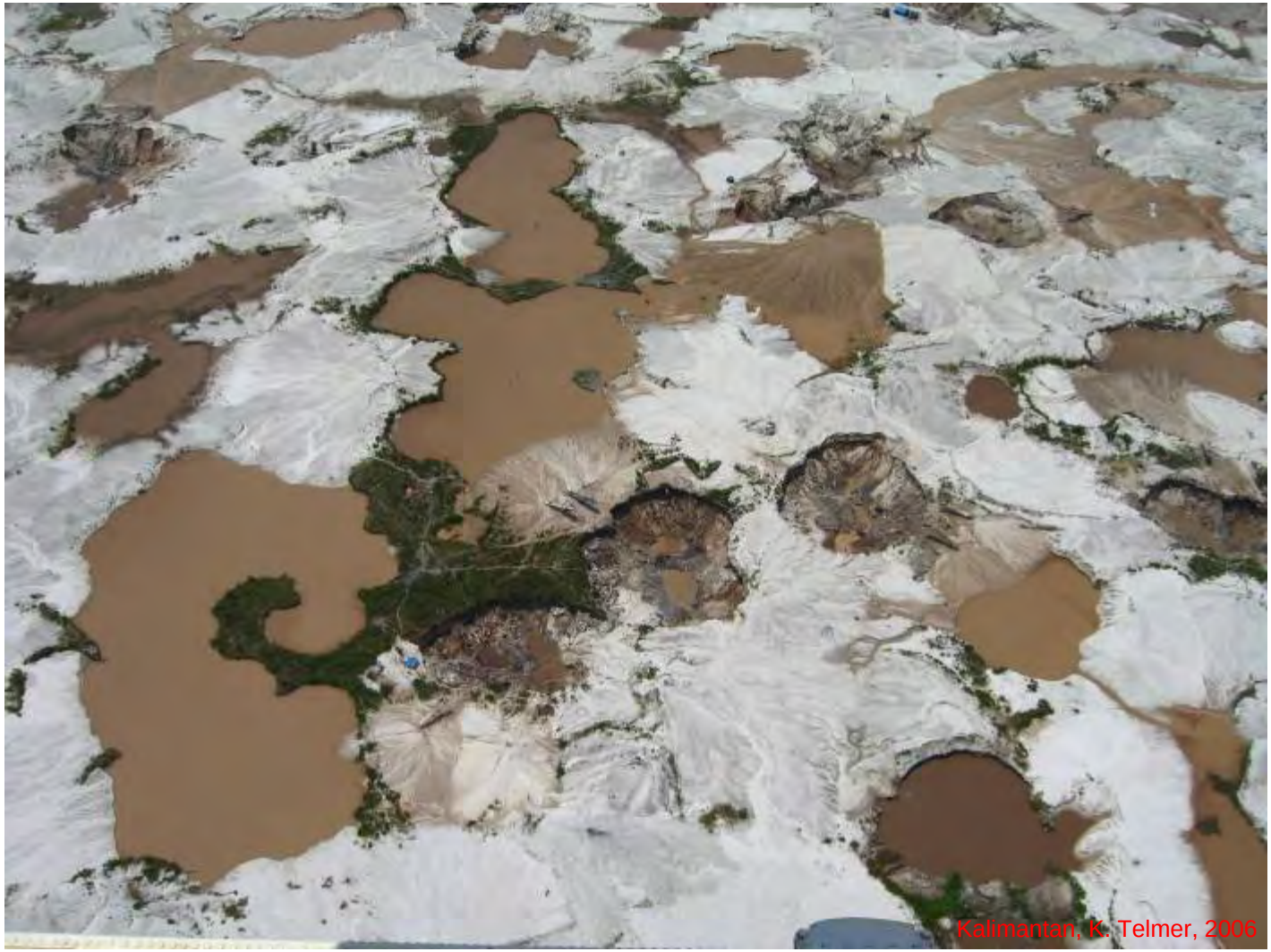
Thousands of Amalgamation ponds and mining pits

One of many growing operations



Aerial View

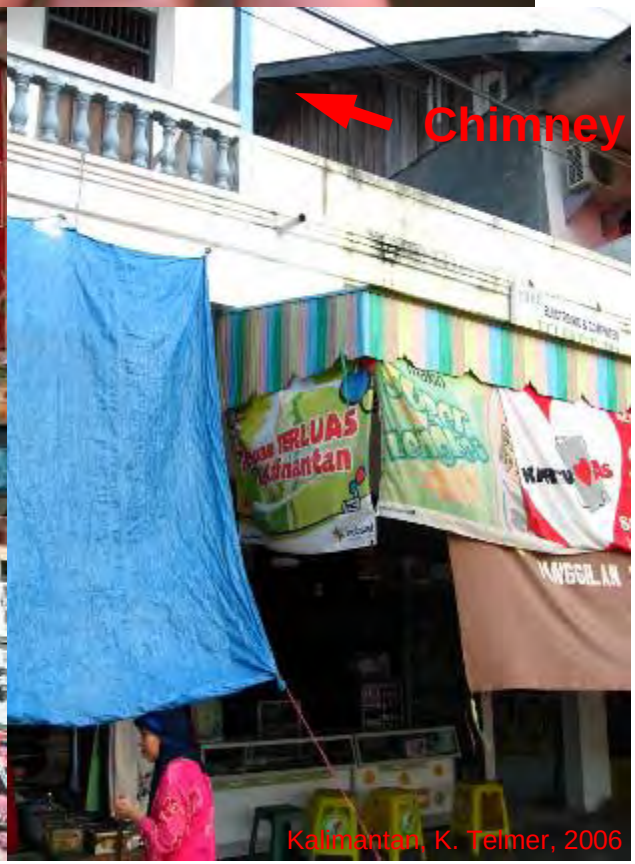
Mining Pits & Amalgamation Ponds



On the ground


Kalimantan, K. Telmer, 2006

Kalimantan, K. Telmer, 2006



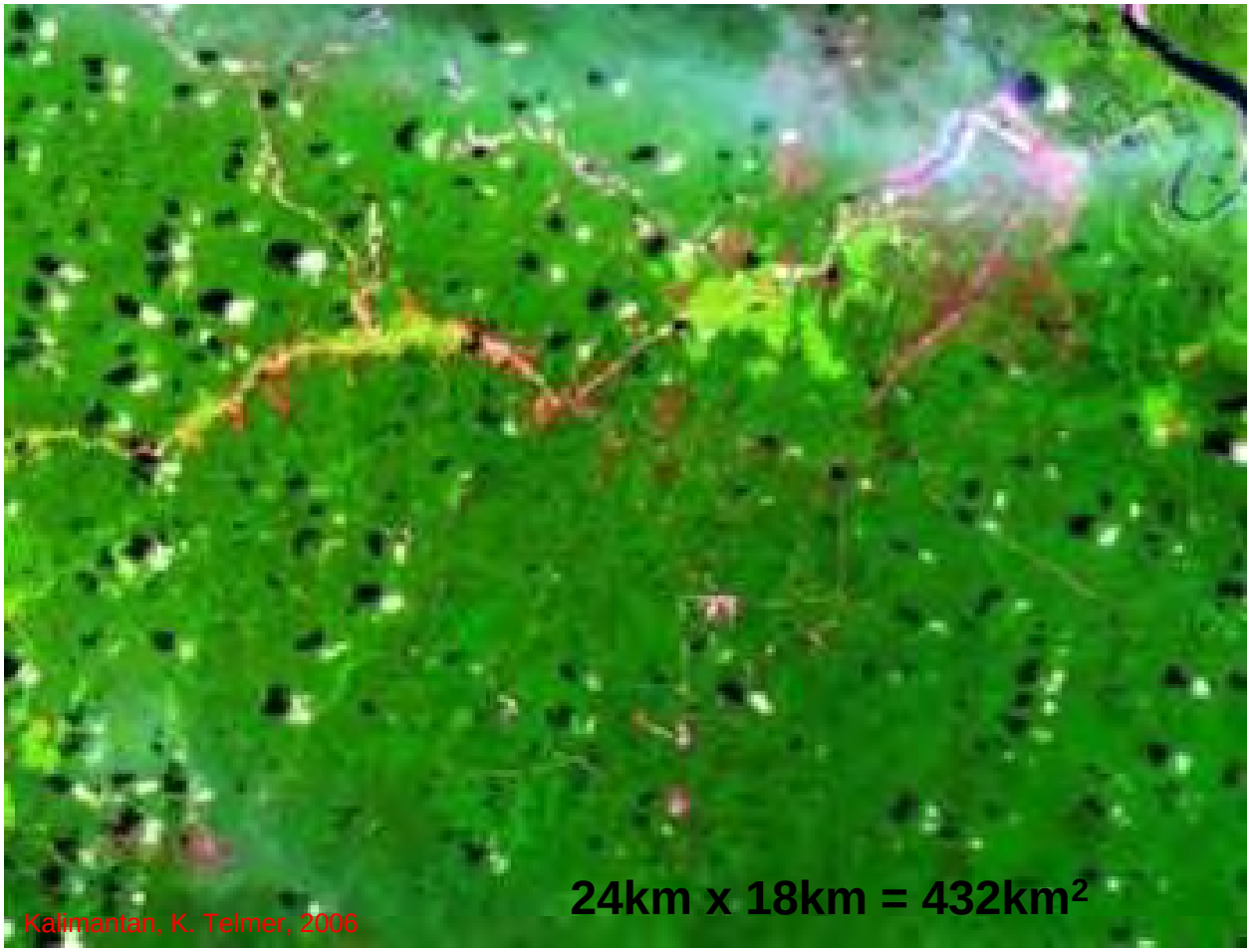
Kalimantan, K. Telmer, 2006

Ignorance

Rates and Amounts

1989 - zero

Primary forest cover is extensive



Processed Landsat 5 TM Image: R=5, G=4, B=3

1999

Huge changes! Extensive forest removal and vast area of mined sands.

Processed Landsat 7 ETM+ Image, R=5, G=4, B=3

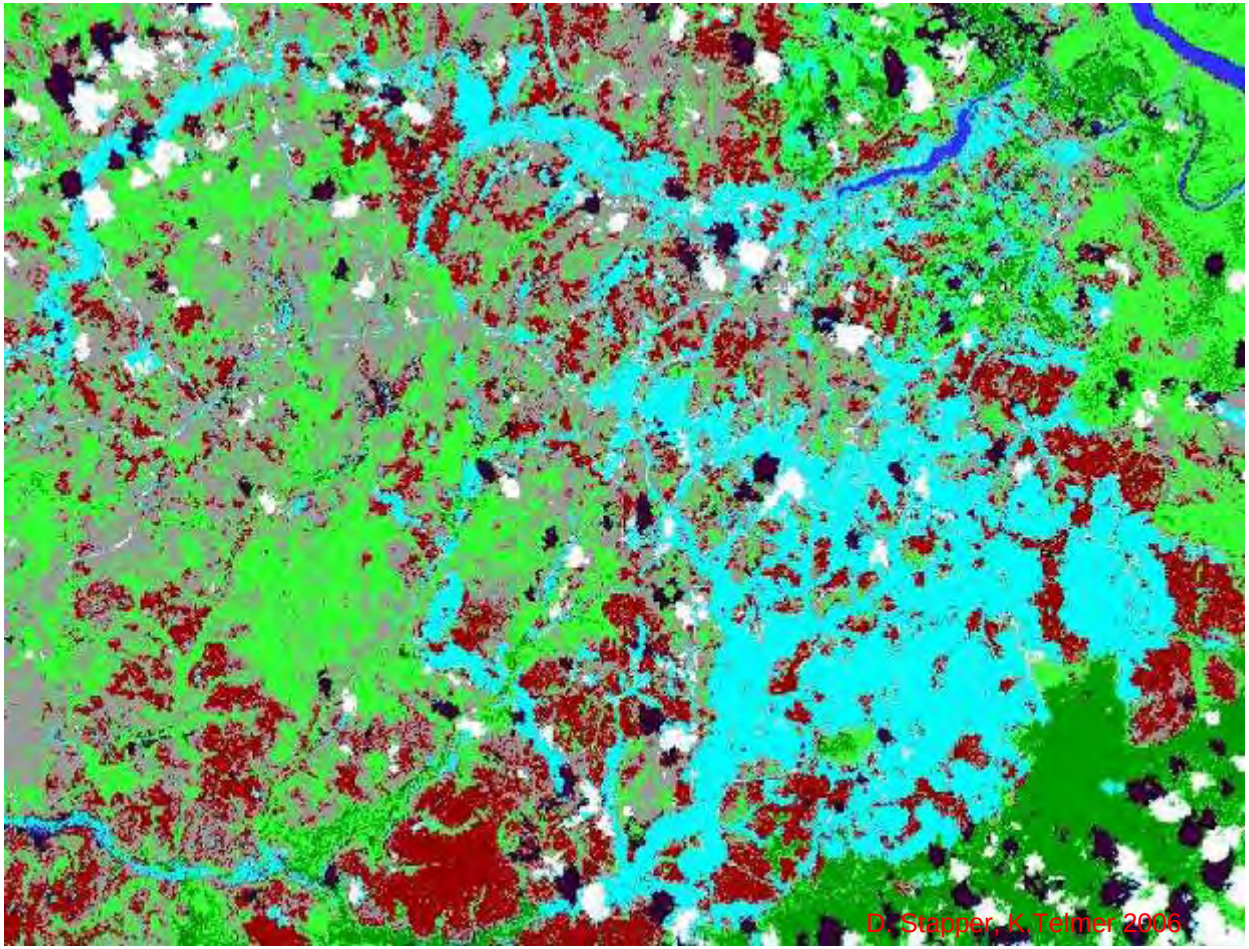
Image classification reveals mined area = 78 km^2 in 1999

Classification:

Sand from Mining (cyan) 78km sq, 18% ± 2%;

Exposed Soil (brown) 64km sq, 15% ± 2%;

Agriculture/disturbed (grey) 117km sq, 27% ± 2%



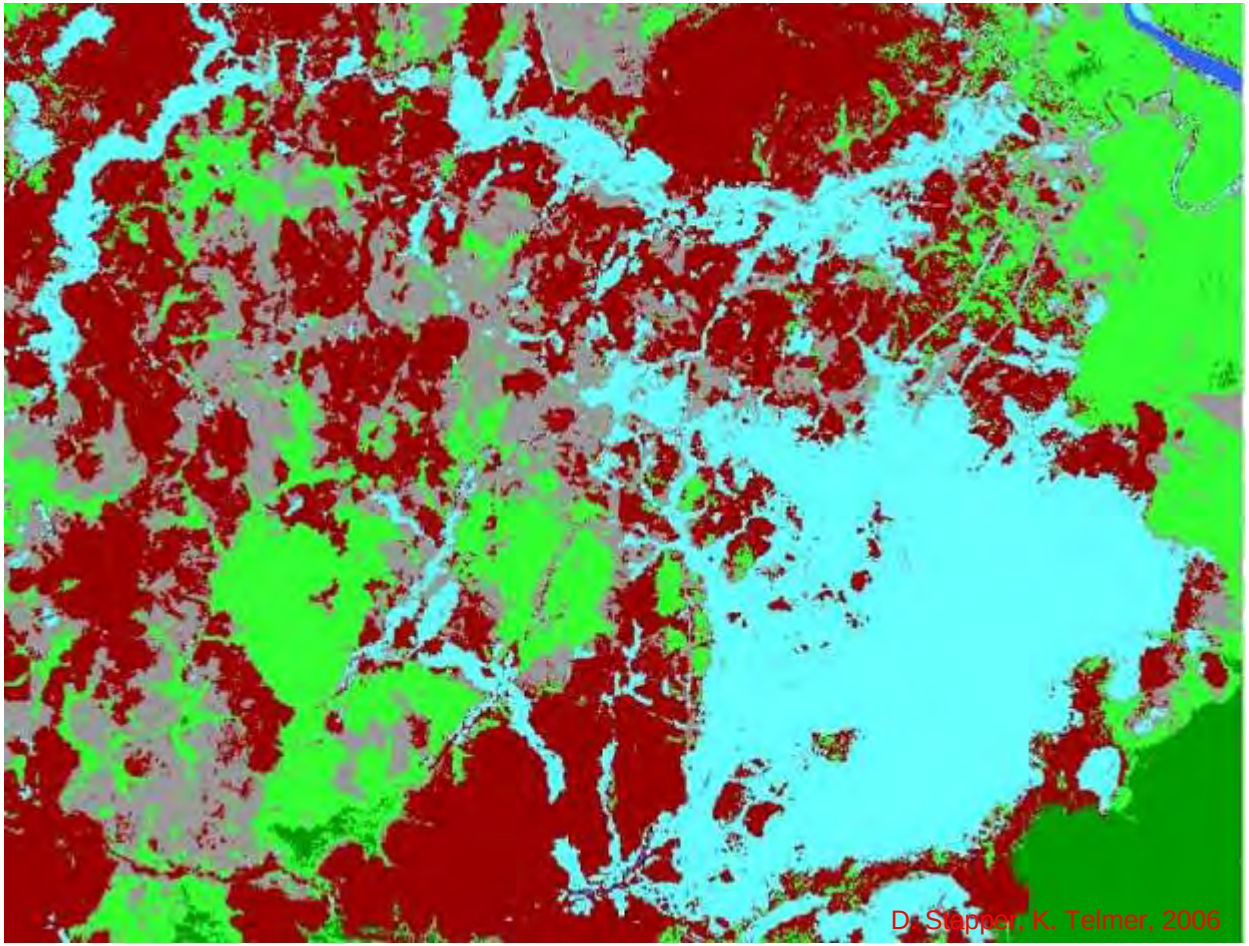
2002 – 102 km^2

Classification:

Sand from Mining (cyan) 78km sq, 18% ± 2%;

Exposed Soil (brown) 64km sq, 15% ± 2%;

Agriculture/disturbed (grey) 117km sq, 27% ± 2%



Since 1990 – 16 years

- Rate of Mining – 8 km^2/y
- Gold recovered = 11.9 t
- Value of gold[1] = $210 Million US Dollars
- $13 Million/year
- $50 Million/year for Galangan Area including Dredges
- Any alternative needs to be this big

1. Determined using gold price variations over time since 1990

Set up and operating costs of operating in Galangan

- Pump + sluice + carpets = 10,000,000 Rp
  - 1000 USD
- Dredge = 15,000,000 Rp
  - 1500 USD
- Simple Zircon setup = 2,200,000 Rp
  - 220 USD
- Generally make back investment in 1 year
- Main cost is fuel (diesel; 4-5000 Rp/L = $0.50/L)
  - 200,000 Rp/day for sluice; 20USD
  - 400,000 Rp/day for dredge; 40USD

Salaries in Galangan

- Basic labourer makes 25,000 to 50,000 Rp/day
  - 2 to 5 USD
- Foreman, perhaps 10 times more; 20 to 50 USD
- Land holder, perhaps 5 times that but varies with holdings
- Mercury Mafia – 1,000,000 USD/year (unknown how many people)

GMP activities to reduce mercury consumption

1. Technology intervention

- Use of **filtered fume hood, condensor unit,** and retort to burn amalgam.
- **Use Hg more efficiently.**
- **Optimize sluice box process** by refining design and choosing good material components.

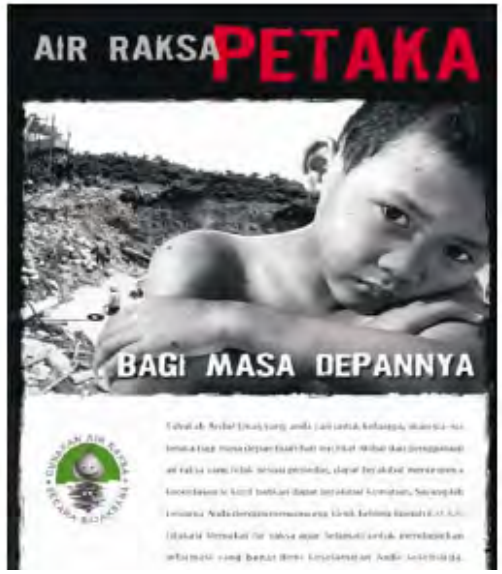
Global Mercury Project

Budi Susilorini, GTFM, GMP, Vienna, 2007

GMP activities to reduce mercury consumption

2. Awareness campaign

- Primary target and secondary target
- Saturation style media campaign : billboards, posters, flyers, stickers, broadcast media, and UNIDO booklets
- Direct consultation
- Film screening



Global Mercury Project

Budi Susilorini, GTFM, GMP, Vienna, 2007

Measured Success

- Increased awareness of mercury hazard
  - Public 41 to 83%
  - Gold Shop Owners 83% to 100%
  - Women 14% to 91%
  - Miners 21% to 93%
- Reduced Mercury Consumption
  - 17 out of 35 gold shops have installed the water condenser fume hood to capture and recycle mercury

Case III: Amazon Basin River Dredges

K. Telmer, Tapajos River Basin, 1997

Dimension of artisanal gold mining in Brazil and in Tapajós region

- ✓ 100,000 artisanal gold miners (garimpeiros)
- ✓ 40,000 in the Tapajós region. Reached 200,000 miners - mining peak in 1990
- ✓ 2,000 mining sites (garimpos)
- ✓ 432 air strips
- ✓ 6 to 8 tonnes/year of gold in the Tapajós region
- ✓ Major costs: Diesel, transportation, tools, Mercury (US$200/kg) and food

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

Bausa

Para, Brazil, K. Telmer, 1997

Romulo Angelica, Para, Brazil, K. Telmer, 1997

Pristine and Impacted

One man operation

Para, Brazil, K. Telmer, 1997

Para, Brazil, K. Telmer, 1997

Para, Brazil, K. Telmer, 1997

GMP Actions - 02

5. Introduction of biosand filters to be tested in the mining sites

6. Distribution of retorts to disseminate the culture of protection against mercury vapour during the amalgam burning

7. Mercury recycling and reactivation

8. Implementation of pilot plant for training on gold processing, including hammer mill, ball mill and a new centrifuge

Fume hood installed by USEPA

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

Pool for amalgamation of concentrate

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

Use of retort to burn amalgam

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

Economics of Mercury: Case I

- **Case I: Amalgamation of whole ore followed by cyanidation**
  - Greatest mercury consumption per unit of gold (20:1 to 50:1)
  - Mercury is currently 10% of direct operating costs; and perhaps another 5% due to increased labour costs
  - To increase profits, miners with sufficient capital already do not use mercury
  - Technologically and socio-economically, it is possible that mercury consumption can be drastically reduced quickly and ultimately, completely replaced
  - Eliminating mercury would not eliminate the local gold economy
  - An increased mercury price will help drive this change

Economics of Mercury: Case II

- **Case II: Amalgamation of gravity concentrate from alluvial workings**
  - Consumption is about 1.3 units of mercury per unit of gold produced
  - Cost of mercury is less than 1% of gold revenue and the amount used is not controlled by the miners directly
  - 1% of a 50 million dollar per year economy is $500,000 dollars
  - Gold shop owners have been eager to recover and recycle mercury for profit
  - An increased mercury price will increase incentives to recover and recycle mercury

Economics of Mercury: Case III

- Case III: River Dredges, Kalimantan and Brazil
  - Consumption is about 1.3 units of mercury per unit of gold produced
  - But the once the mercury becomes “dirty” it is discarded raising the consumption rate to 3 to 5 units of mercury per unit of gold recovered
  - The mercury is purchased directly by miners
  - Cost of mercury is less than 2% of gold revenue but these operations run at near the break even point and so buying mercury is considered a significant cost by the miners
  - Each miner makes $12 to $30 per week
  - Mercury costs per miner are around $2.5 dollars per week (10 to 20% of earnings)
  - An increased mercury price will increase incentives to recover and recycle mercury

Determined Mercury Conservation

Main message

- A ban on mercury trade by the US will stimulate mercury conservation at ASM operations

But there are other important considerations

- A huge price increase or rendering all mercury contraband may have unpredictable outcomes
  - Increased incentive to smuggle
  - Underground mercury trade
  - Already occurring in some places
- It is easier to eliminate mercury from some ASM operations than others
  - A very high price ($2000/kg) will still only represent 10% of costs for some operations so price alone will not solve the problem
- Field based intervention programs like GMP must also continue

Ethics

- Increased costs are passed on to the poorest
- Export bans represent a unilateral action which arguably can impoverish or further indenture the poor
- By most human rights criteria, we should not knowingly induce small scale miners to take a pay cut
- An export ban therefore needs to be accompanied by the development and implementation of viable replacement technologies or replacement economies for small scale miners
- Don’t squeeze people to change but rather help them to change
- Field based intervention programs like GMP must remain a priority

The keys to eradicate mercury in ASM

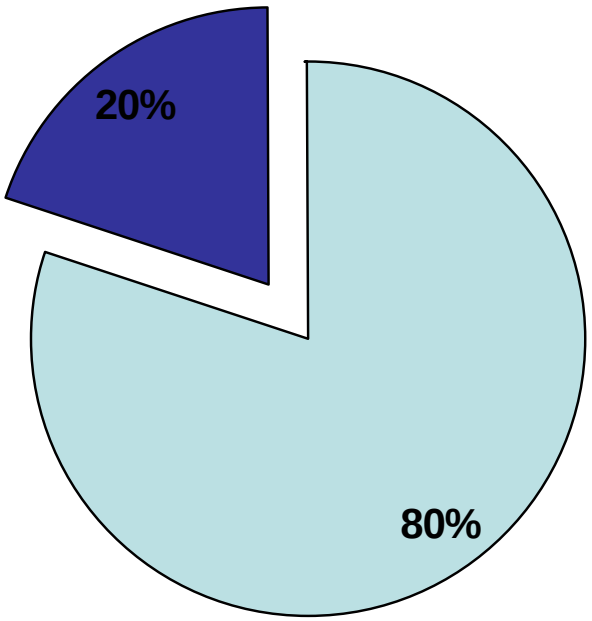
- Making Hg less available
- This is equivalent to making it more expensive
  - Trade Bans
- Providing an alternative
  - Alternative method of small scale gold mining
  - Alternative economy

Mercury Reduction Goal – 50% in 10 years

- By eliminating whole ore amalgamation, improving practices, and supporting export bans, the GMP believes that a 50% reduction in mercury demand in small scale mining is attainable in 10 years time (by 2017)

Three Scenarios

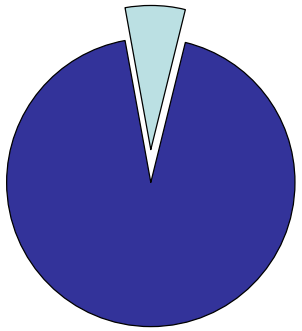
Current - 2007



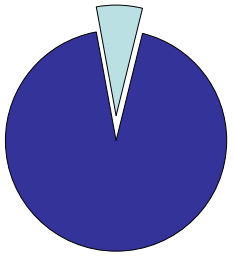
1000 Tonnes

2017

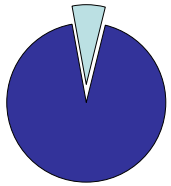
500 Tonnes: elimination of whole ore amalgamation



400 Tonnes: also use of retorts



200 Tonnes: also mercury-free alternatives



Concluding Remarks

- Miners are sensitive to the price of mercury and already seize any opportunity to conserve it
- Therefore a ban on mercury trade by the US will stimulate mercury conservation at ASM operations
- Limiting supply is an important step in reducing mercury consumption in ASM but is not a silver bullet to the problem
- Field based intervention programs such as GMP must also remain a priority

- Thank you!