Global Mercury Project

Mercury and Small Scale Gold Mining – Magnitude and Challenges Worldwide

Indonesia, 2006

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Outline

- Opening remarks
- ASM and mercury
- Global magnitude
- Health and Environmental Impacts
- Mercury Trade and ASM
- GMP’s strategy for reducing mercury use in ASM – 4 keys, 2 phases
- Policy and Governance
- Attainable goals in the next 10 years

How many here have been to an ASM site?

What is GEF/UNDP/UNIDO GMP?

- GMP Teaches, assesses, and innovates best practices in technical know-how and governance (local to international) to assist small scale miners move towards cleaner technologies, sustainable livelihoods, and better health
- Essentially it is a field operation (local communities) but with frequent visits to national and international governments and partners
- In the afternoon Bardolf Paul will give an example of GMP field opps in Indonesia, which is ripe for success

Global Mercury Project Sites

Two Phase Approach

Two phase approach to capacity building in technical know-how and governance.

Financial incentives are the core motivational force

- Less Mercury, **More Gold**, Better Health (Phase I)
- Zero Mercury, **More Profits**, Better Health (Phase II)

Perspective

- Gold = money
- Gold mining is equivalent to printing money
- Through bad practices, the miners frequently leave more than 50% of the gold behind while polluting the world with mercury
- If we teach miners how to get a little more gold while reducing mercury use, the change ***pays for itself***
- Being a good citizen also counts, but not as much
- If mercury is expensive, then using less also pays – but this is ethically tricky
- We, the developed world, the authorities, whoever, should not be asking small scale miners to take a pay cut – nor inducing one
- Lets not squeeze people to change but rather help them to change – empowerment!

ASM Overview

- 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**.
- Perhaps 100 million people indirectly involved and potentially exposed

What is ASM?

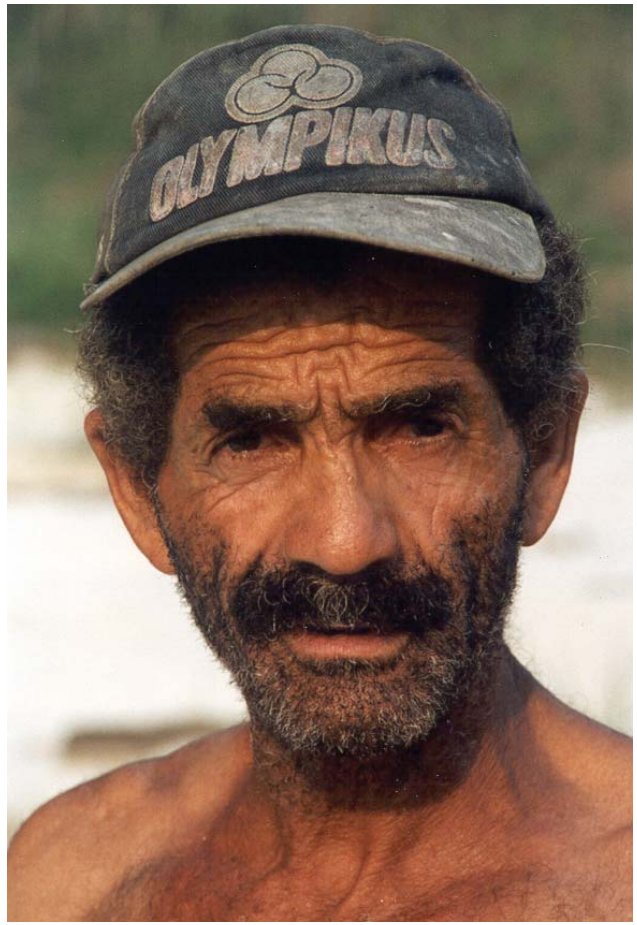
- Artisanal & small-scale mining (ASM) encompasses all small, medium, informal, legal and illegal miners who use rudimentary processes to extract minerals from secondary and primary ores

ASM and mercury

- Occurs across a vast geographical area (55 countries) – highly decentralized Hg source
- Operate in the informal economic sector, often illegally and with little organization
- Miners have little or no economic capital
- Important source of wealth
- Highly diverse cultural, political, economic and physical settings
- Many different types of gold-ore
- Many different mining techniques are used
- There is no single technological “silver bullet” to move to a mercury free system

Why is Mercury Used?

- Very easy
- Very independent – 1 person can do it
- Effective
- Accessible
- Cheap (1g Hg = $0.02; 1g Au = $20; 1:1000)
- Miners are not aware of the risks
- No choice



Brazilian miner with Tremors, 1996

Mercury in ASM

- As a consequence of poor practices, at least 650 to 1000 tonnes of mercury per year are released
- 1/3 of all global anthropogenic releases
- ASM is the single largest intentional-use source of mercury pollution in the world

Extensive global pollution

- Severe occupational hazards – Mercury vapour
- Tens of thousands of polluted sites with far reaching impacts
- Long-term environmental health hazards to populations and ecosystems (lots of MeHg)
- 300 tonnes of mercury per annum are volatilized directly to the atmosphere
- 700 tonnes are discharged into soils, rivers and lakes.
- Contaminating both international waters and air

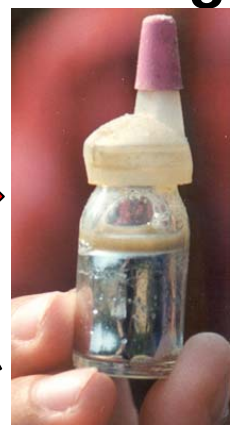
MeHg Production

- Big MeHg production still continues after 100 years from historical workings and tailings
  - Susan Winch, PhD dissertation
  - USGS
- Only need to Methylate a very tiny fraction of mine waste to have huge problem
- Methylation Potential due to Inundation (annual flooding)
  - 7 % of the Crepori Basin, Brazil
  - 500 km^2 of the Tapajos River downstream of mines

How is mercury used?

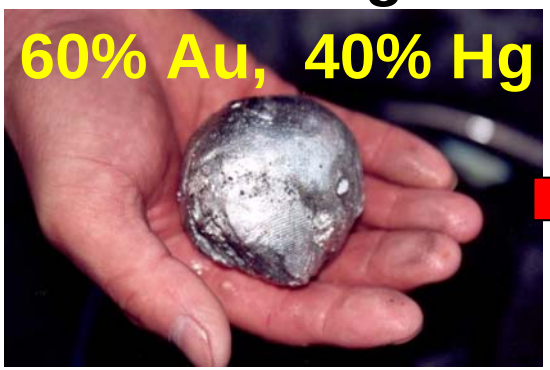
Gold + Sand

Add mercury to dissolve gold



Tailings

Form Amalgam



Evaporate

Gold Residual

Example
Dredge and diver vacuuming and sluicing sediment

Brazilian Amazon, Tapajos Basin

Original Water Quality

Heavy gold particles sink and get trapped in carpets

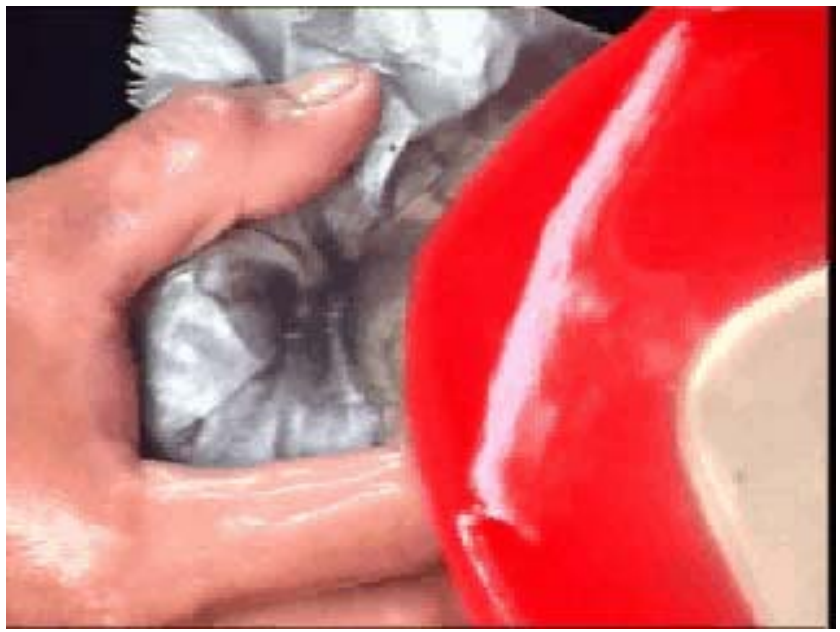
Brazil, Tapajos Basin

One man operation (had malaria!)

Brazilian Amazon,
Tapajos Basin

Collect gravity concentrate from carpets and amalgamate it

Remove excess mercury from amalgam by squeezing



Indonesia, 2003

Amalgam

Open air amalgam burning

Sponge gold (still has 5% Hg)

Bring sponge gold to town

Brazilian Amazon, Povoado do Creporizao, Tapajos Basin

Sponge gold is melted, mercury is emitted

Pour an ingot

7 g Gold

Go to the
jeweler
and
buy some
groceries

Causes of poor ASM practice

- **Disorganization & transience**
- **Lack of general education**
- **No technical assistance**
- **Financial barriers**
- **Rejection by mainstream society**
- **Inadequate/Inappropriate regulations**
- **POVERTY**

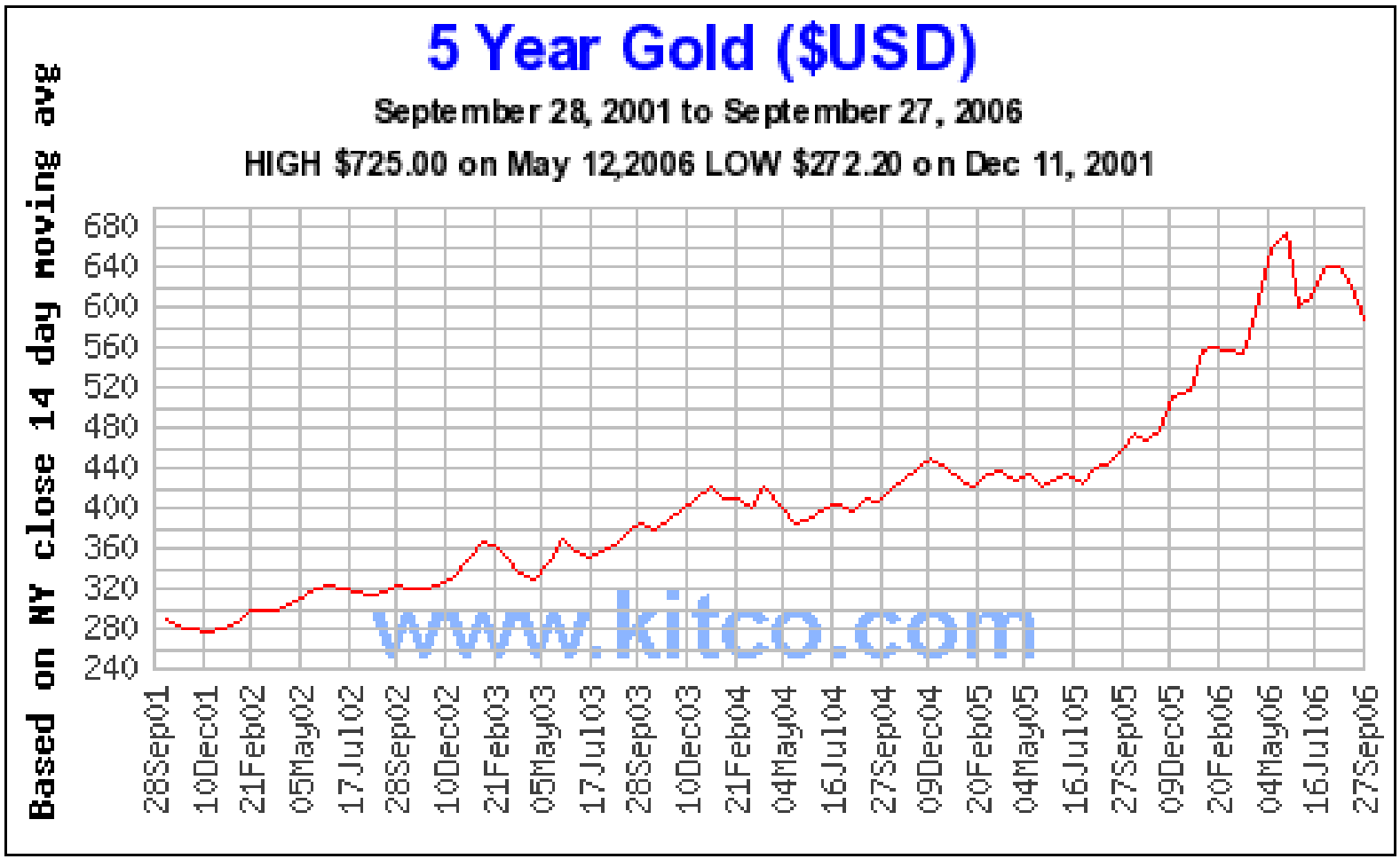
Tanzania, 2000

Gold Rush and Poverty

- Mercury demand in ASM continues to increase
- With gold rising from US$260/oz in March 2001 to US$725 in May 2006, a gold rush involving poverty-driven miners is being observed in many countries
- This increase in mining activity is compounded by the failure of subsistence economies, conflict causing displacement of populations, and diseases such as HIV/AIDS
- On the global scale, mercury use in ASM may be growing to a historically unprecedented level

The world's biggest gold rush is now!

Increasing price = More people involved



ASM touches all of the UN Millennium Development Goals

- **Eradicate extreme poverty and hunger**
- **Promote gender equality and empower women**
- **Reduce child mortality**
- **Improve maternal health**
- **Combat HIV/Aids, malaria and other diseases**
- **Ensure environmental sustainability**
- **Achieve universal primary education**
- **Global partnership for development**

ASM hotspots

- China (with 200 to 250 tonnes released),
- Indonesia (100 to 150 tonnes)
- 10 to 30 tonnes in each of Brazil, Bolivia, Colombia, Ecuador, Ghana, Peru, Philippines, Venezuela, Tanzania and Zimbabwe.
- 40 other countries

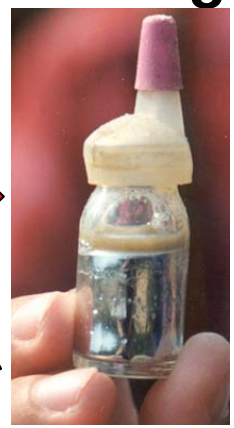
Mercury Consumption in ASM

- 1 to 3 grams of mercury is lost to the environment for every gram of gold produced
- The ratio varies with the technique used which is influenced by habit and social, and economic factors
- When mercury is less available and/or more expensive, less mercury is consumed
- More efficient or zero mercury methods are adapted

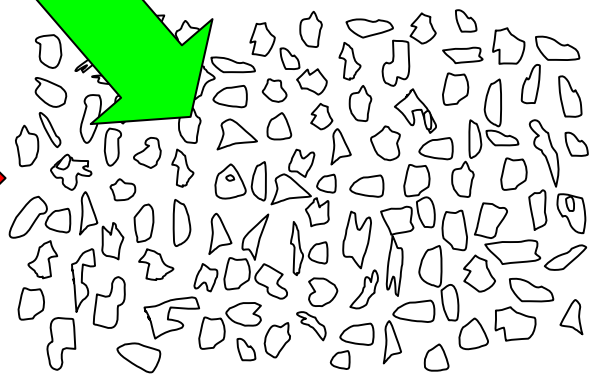
Where is mercury lost?

Gold + Sand

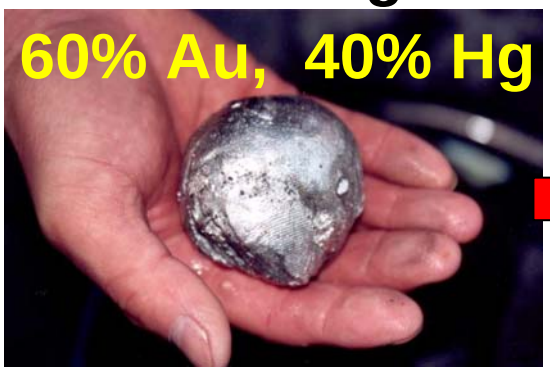
Add mercury to dissolve gold



Tailings



Form Amalgam

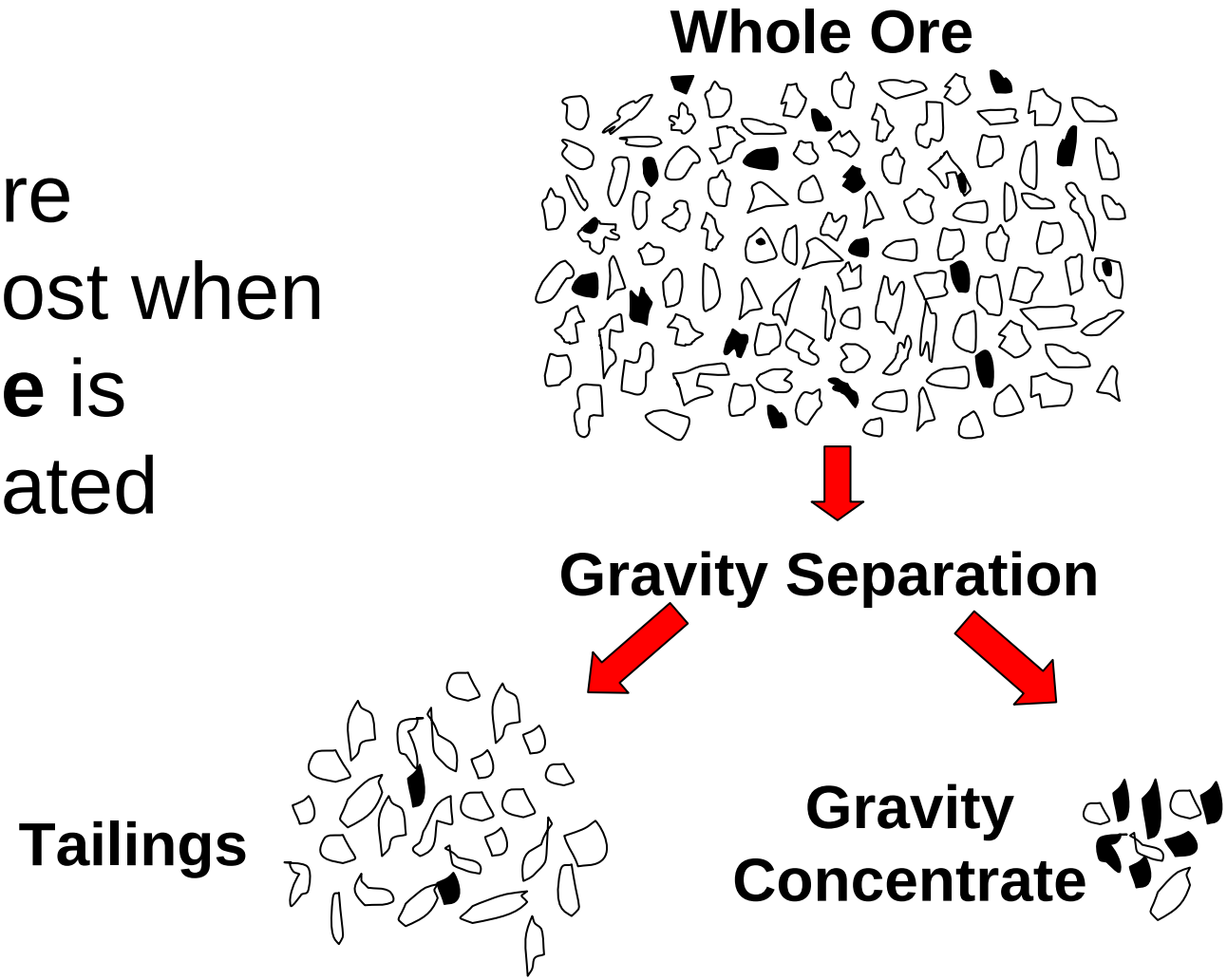


Evaporate

Gold Residual

Do Hg losses vary with style of operation? YES

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



Whole ore amalgamation is bad!

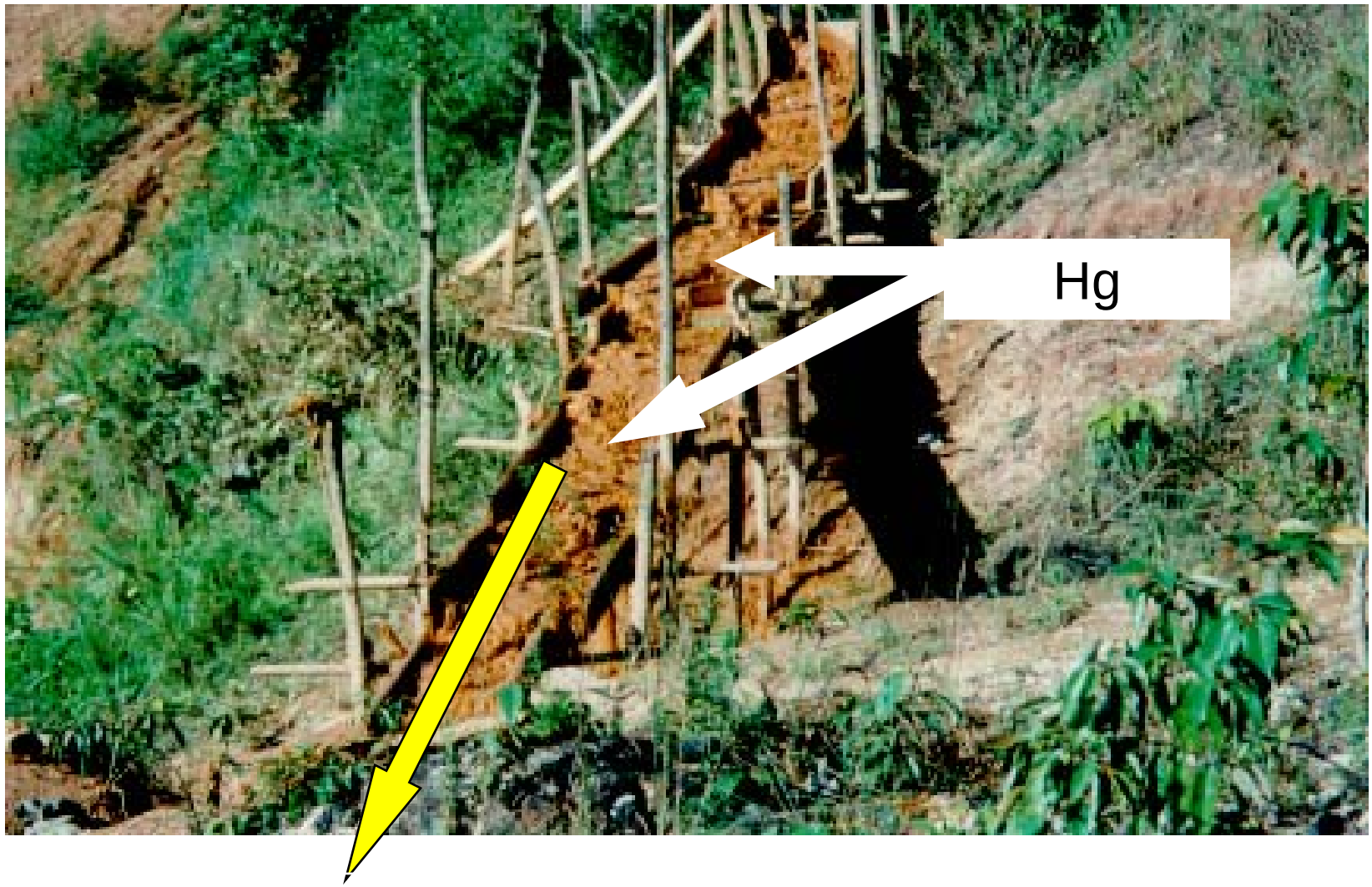
- ***Whole ore amalgamation*** is the largest point source of mercury pollution in ASM (contributing more than 50% of mercury lost in ASM)
- Driven by
  - habit rather than economics
  - availability of inexpensive mercury
  - lack of technical knowledge/expertise
  - lack of organizational support
  - lack of environmental health awareness
- Cost-efficient alternatives to replace whole ore amalgamation exist
- A rising mercury price will help eliminate this

Mercury lost versus mining style

Amalgamation Method	***Hg_{lost} : $Au_{produced}$***
whole ore	**>3***
concentrates, no retort	**~1**
concentrates, with retort	**<1**

* In Sulawesi, Indonesia, as miners add Hg into the ball mills, the ratio Hg_{lost}:$Au_{produced}$ is between 60 and 100

Putting mercury in the sluice box



Hg goes with tailings

Amalgamation of the Whole Ore = Lots of Hg is lost to the Environment

Zimbabwe, 2005

- Use of Copper Amalgamation Plates Generates High Hg-tailings

Amalgamation of the Whole Ore

El Callao, Venezuela, 2003

Amalgamation of the Whole Ore

El Callao, Venezuela, December 2003

Amalgamation of the Whole Ore

Indonesia, 2002

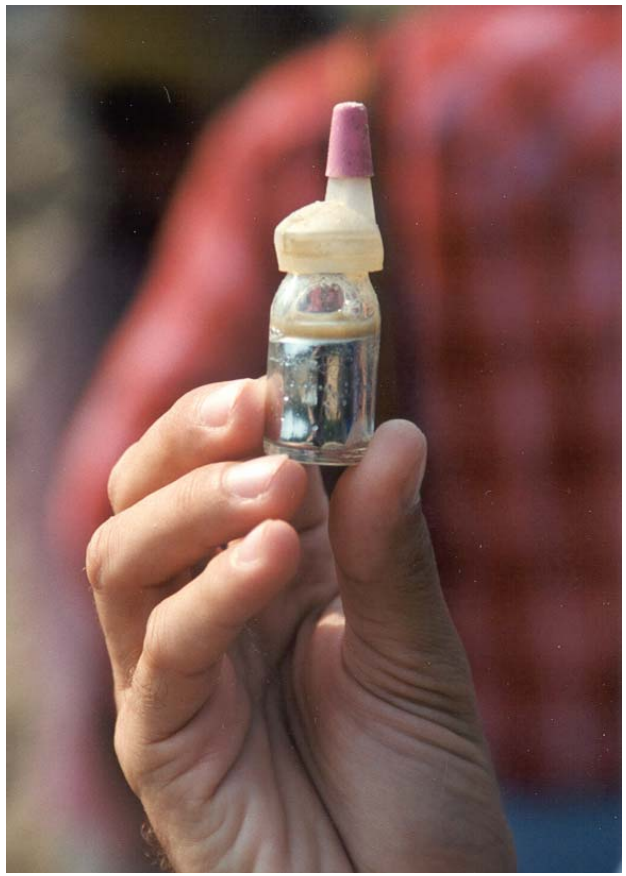
- **In Indonesia: about 110,000 – 350,000 miners (seasonal)**
- **>100 tonnes Hg emitted annually**
- **<u>North Sulawesi</u>: Amalgamation of the whole ore followed by cyanidation**
- **Mercury emitted: 60-90 times the amount of gold produced**

Health and Environmental Impacts

- ASM produces severe health and environmental hazards
- Mobilization of mercury from mine sites into aquatic systems presents a major risk (MeHg)
- Combined use of mercury and cyanide is occurring – the worst possible scenario for mercury mobility and availability

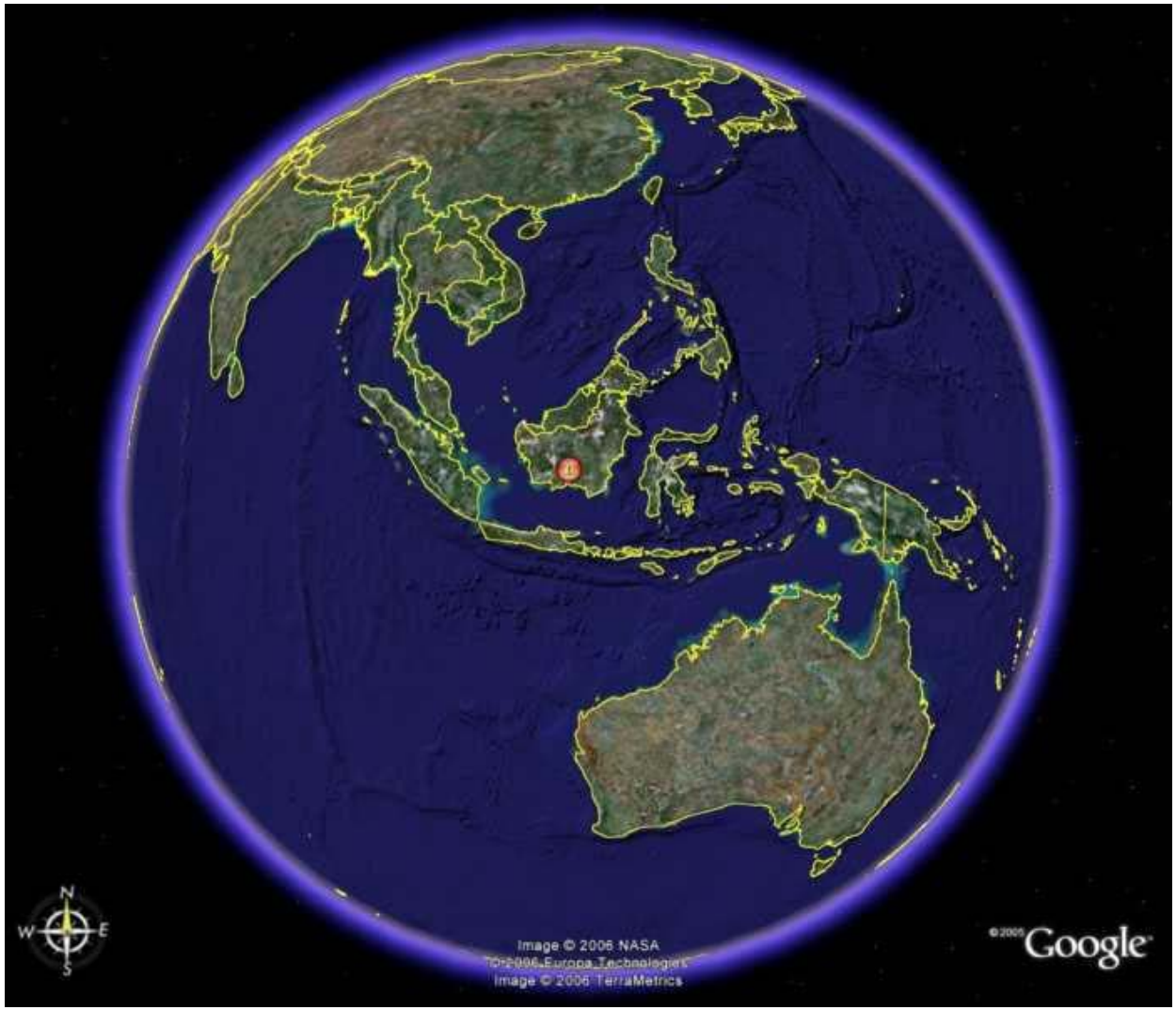
Environmental Problems Caused by Artisanal Gold Mining

- Mercury pollution
- Water siltation
- Landscape degradation
- Destruction of habitats
- Loss of organic soil
- Deforestation



Brazilian Amazon, 2001

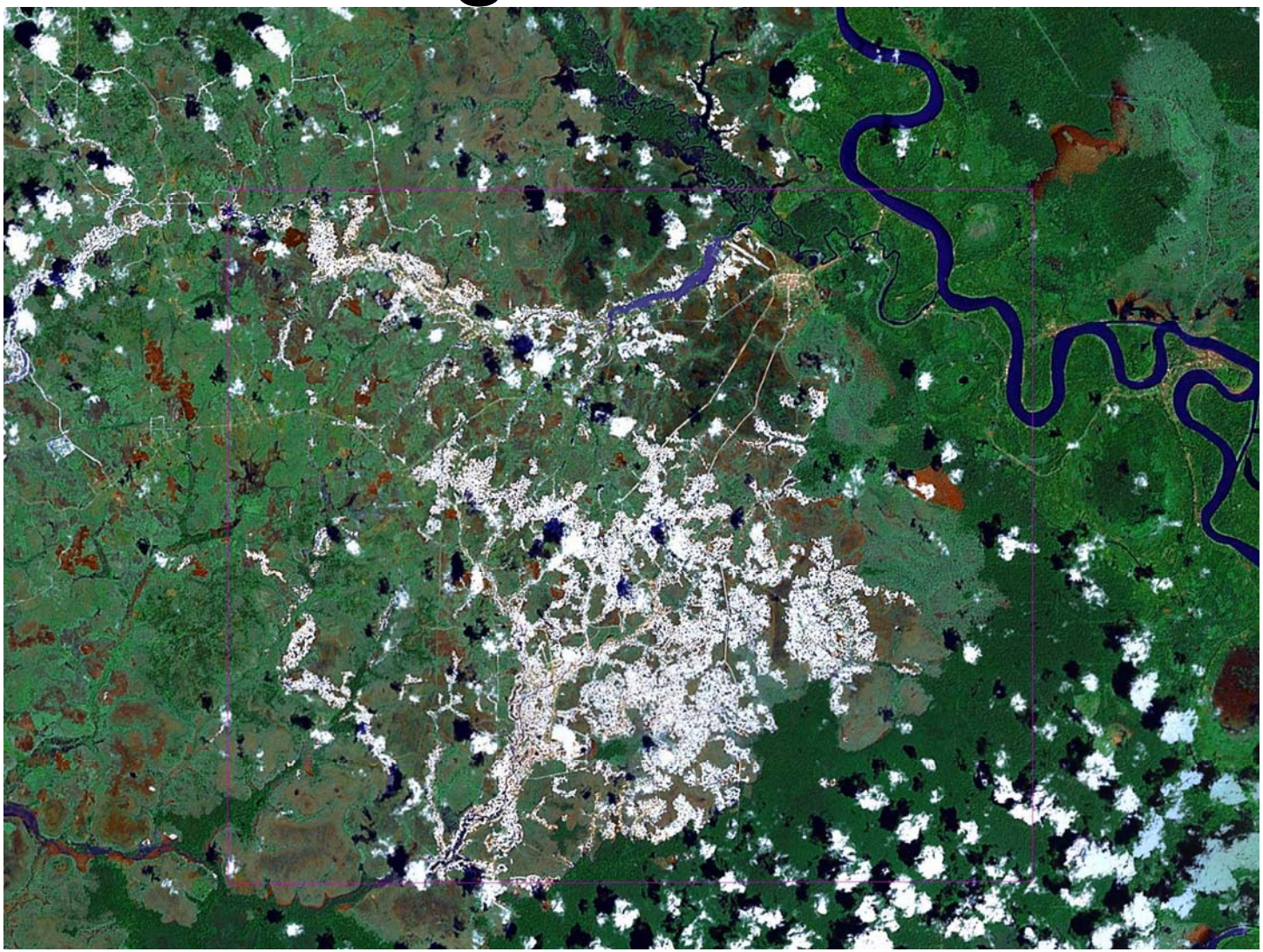
Example - Kalimantan, Indonesia, Island of Borneo



Was habitat for Orangutans

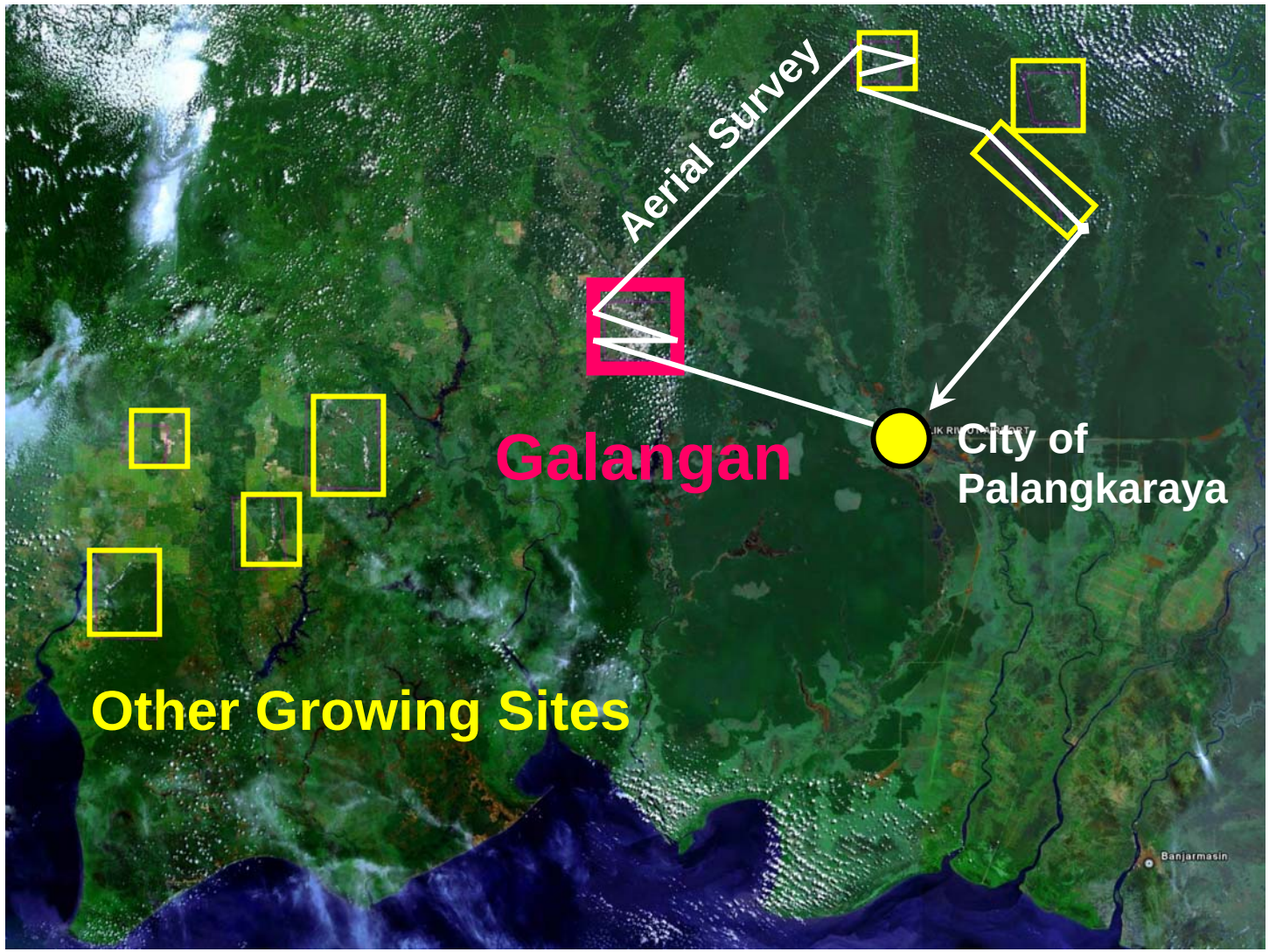
- Only 5000 wild ones left

Galangan – 200 km^2

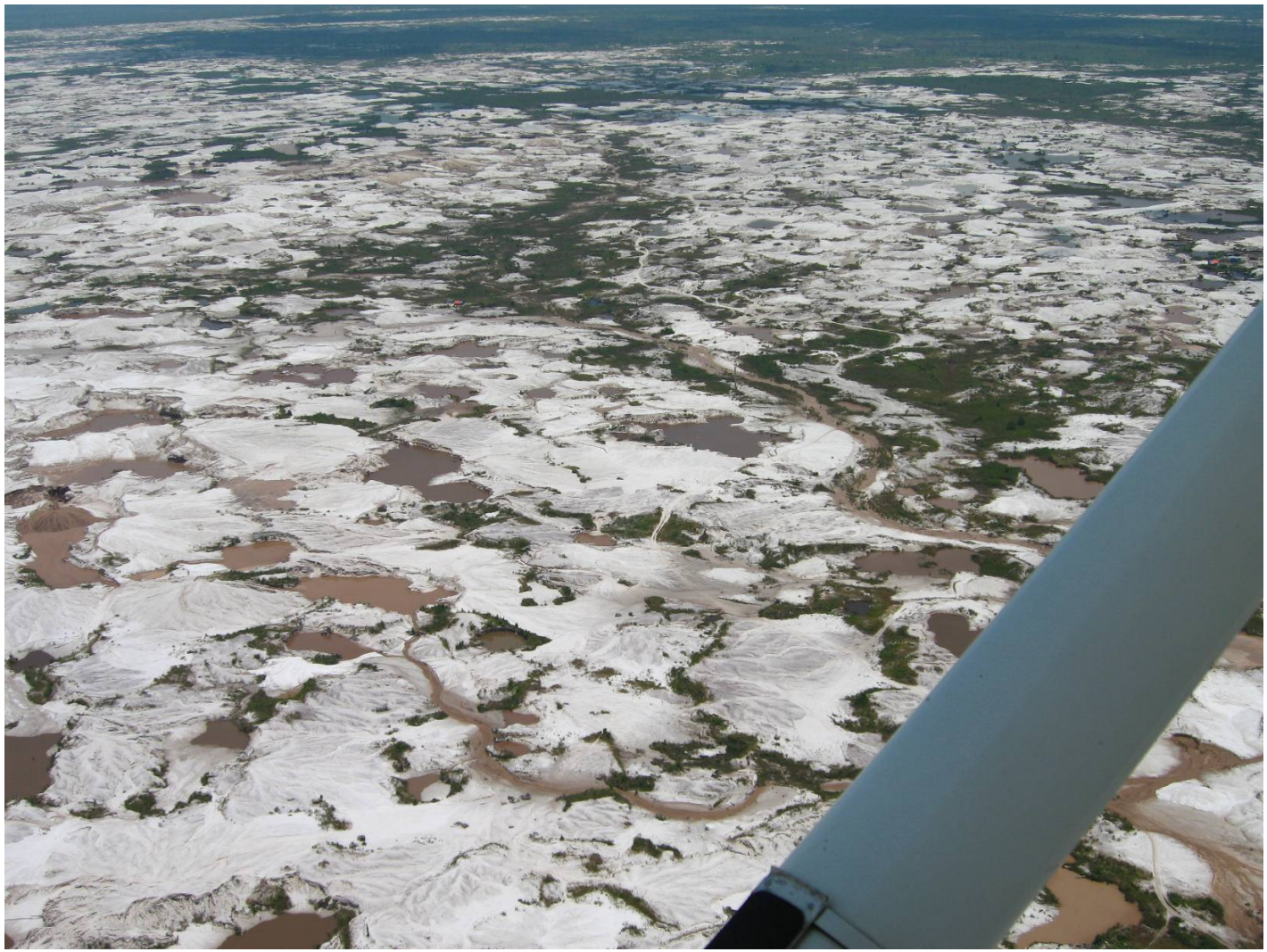


Thousands of Amalgamation ponds and mining pits

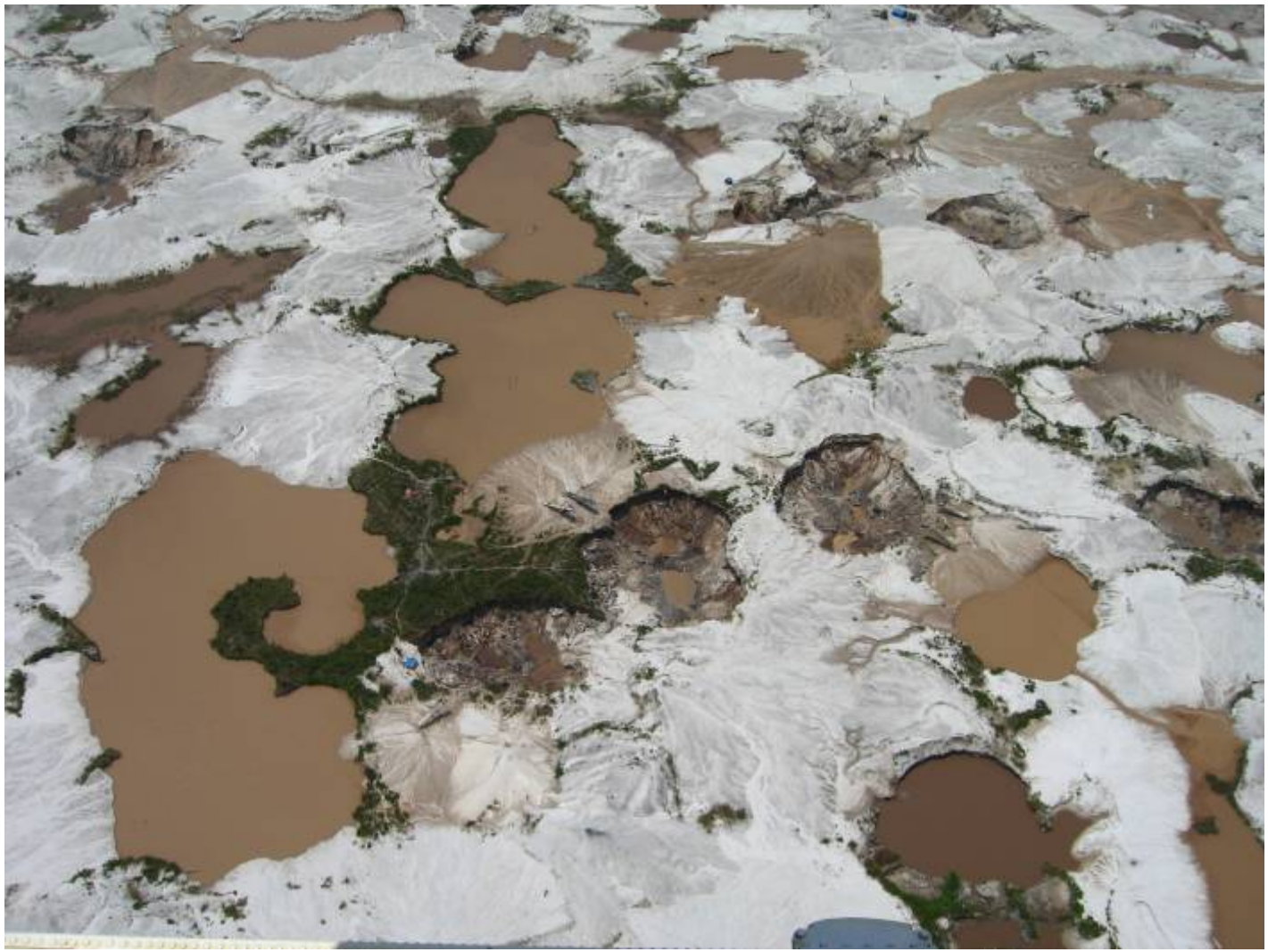
One of many growing operations



Aerial View



Mining Pits & Amalgamation Ponds



On the ground


Chimney

Indonesia

- Second only to China for ASM mercury emissions
- Late bloomer but now really growing
- Combined use of Hg and CN common
- Good conditions for adaptations and changes
- Good candidate for further efforts

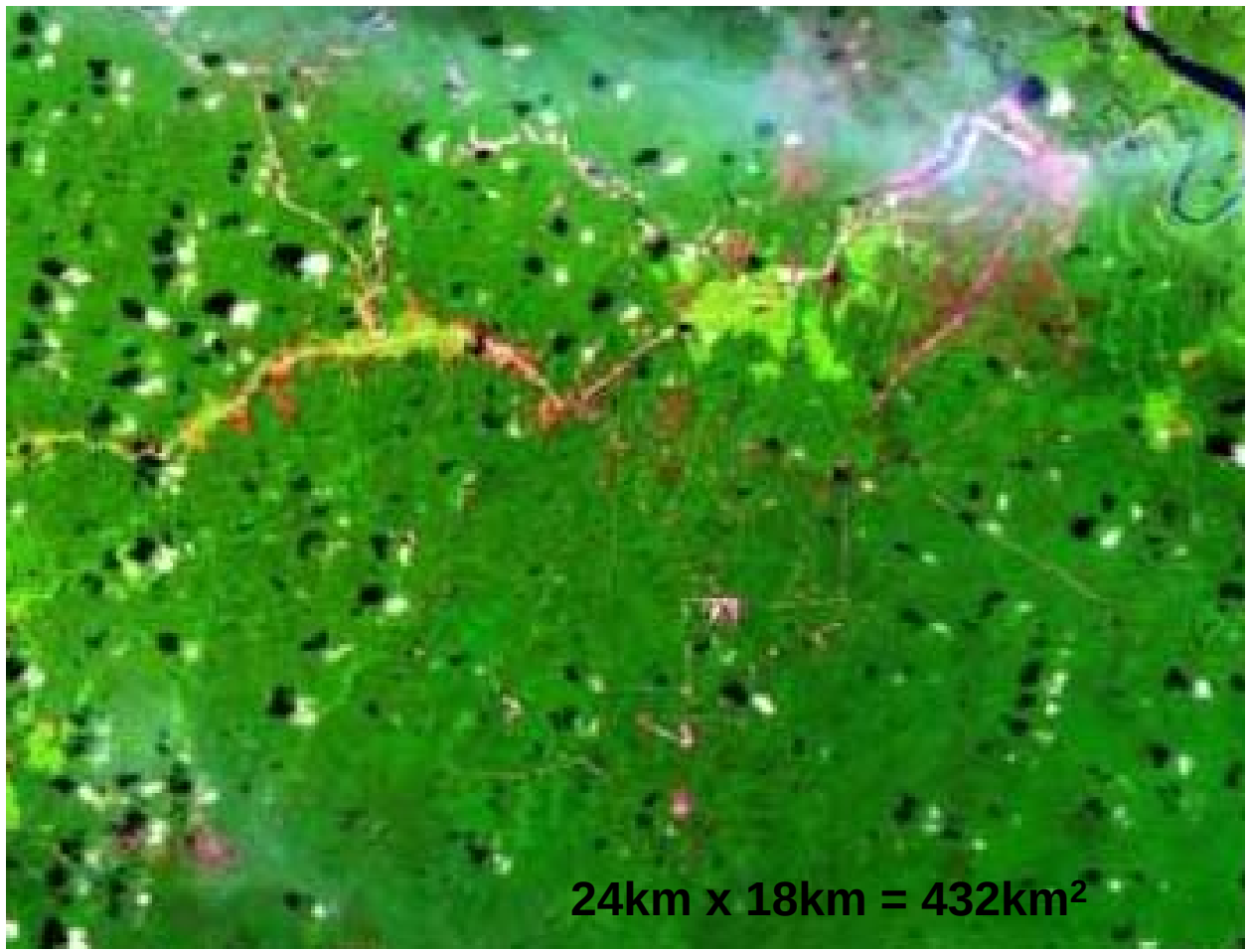
Open Air Burning

- **Fate of emissions?**
- **Almost no studies of comparable sophistication to northern research efforts**
- **Conceptual models and empirical evidence suggest extensive long range transport**

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

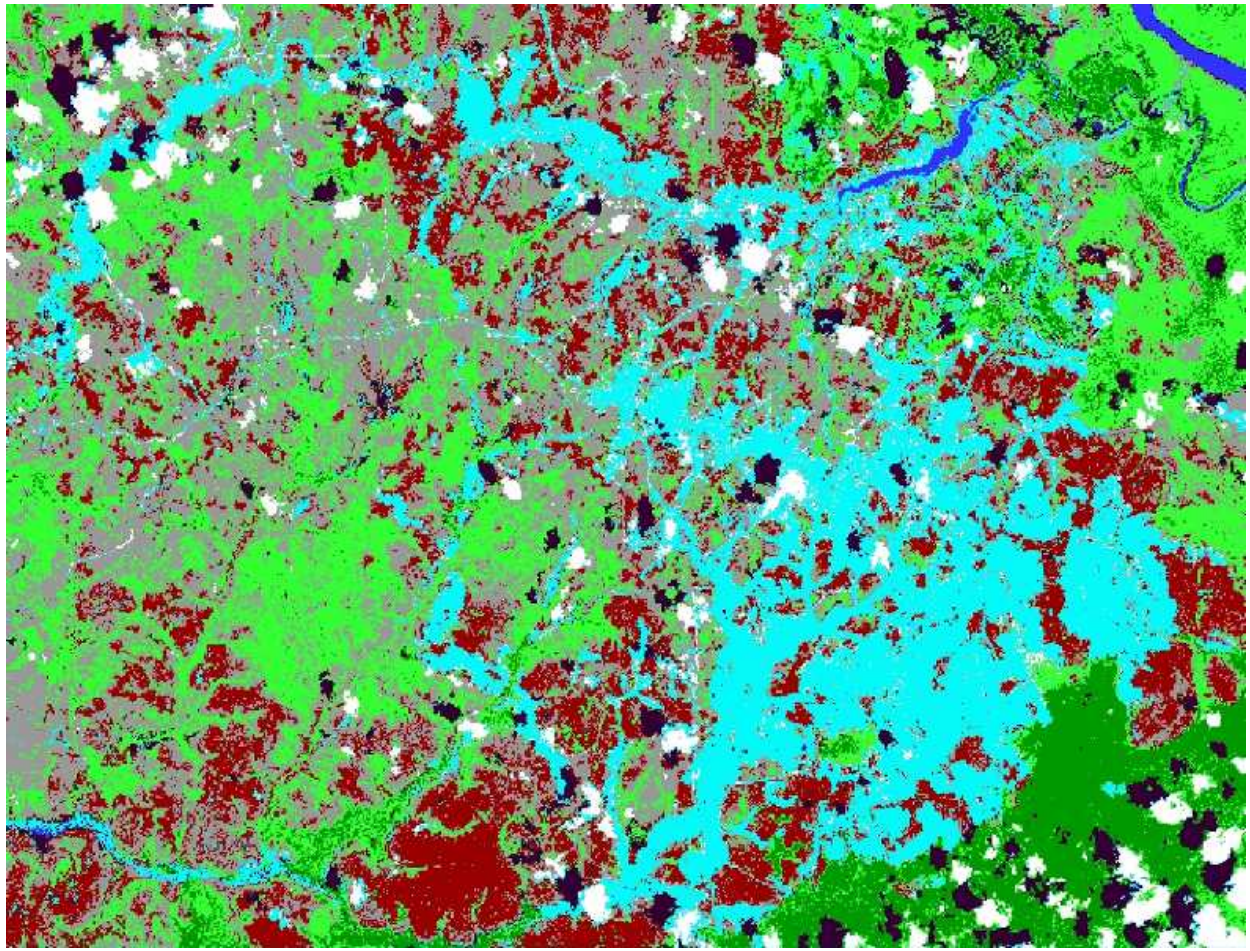
Image classification reveals mined area = 78 km^2 in 1999

Classification:

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

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

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



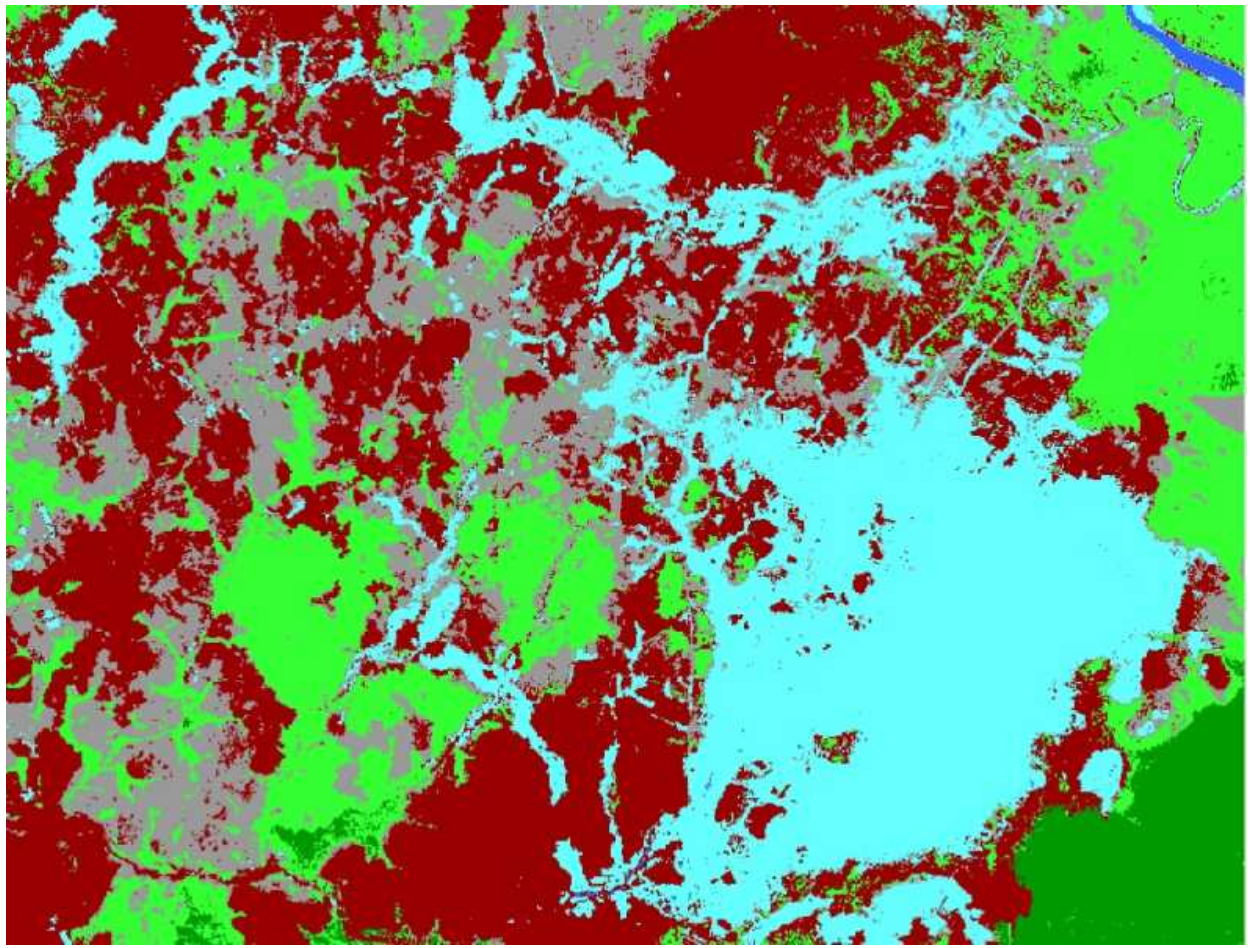
2002 – 102 km^2

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
- Sediment Sluiced 119,574,000 t
- Gold recovered = 11.9 t
- Hg consumed since inception = 59.3 t
- Hg released by amalgam burning = 11.9 t
- Value of gold[1] = $210 Million US Dollars
- $13 Million/year

1. Determined using gold price variations over time since 1990

Wages?

- 5,000 to 10,000 illegal miners
- ~ $2000 US/year
- If it was distributed evenly
- Which it is not

Miners make more money than farmers

- 42% of the people in Sub-Saharan Africa makes US$ 1/day
- Miners in Africa typically make 0.2-1 g/day/miner or US$ 3 to 15/day/miner
- Alternatives must minimally maintain wages!

River Siltation

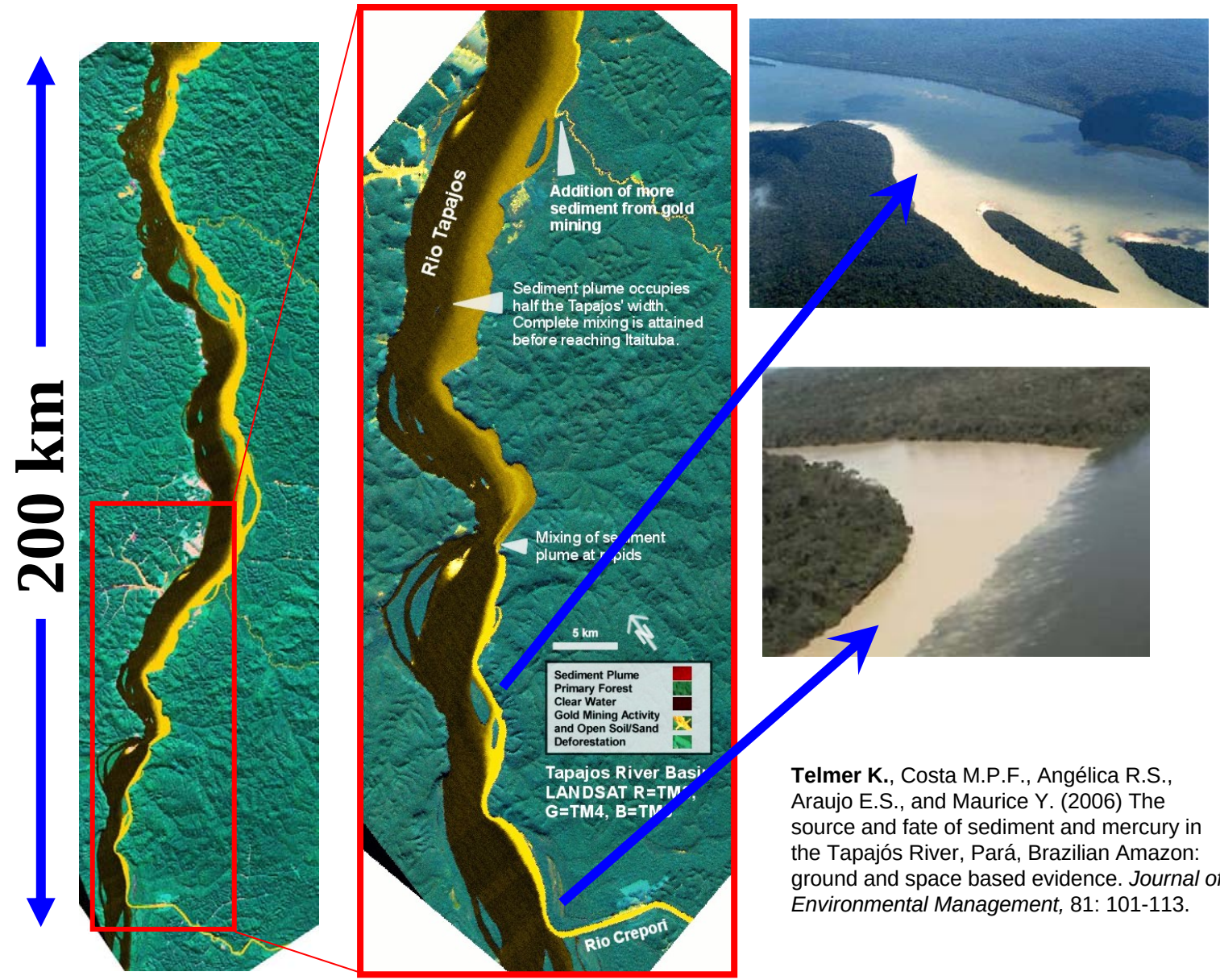
Kahayan River, Indonesia, 2006

River Dredging

Kahayan River, Indonesia, 2006

Sediment Plume, Tapajos River, Brazil

Hundreds of km transport!



Telmer K., Costa M.P.F., Angélica R.S., Araujo E.S., and Maurice Y. (2006) The source and fate of sediment and mercury in the Tapajós River, Pará, Brazilian Amazon: ground and space based evidence. *Journal of Environmental Management,* 81: 101-113.

Combined Hg and CN use

- Amalgamation followed by cyanidation
- Hg becomes more soluble
- Transport & methylation potential increases
- Occurring in many countries

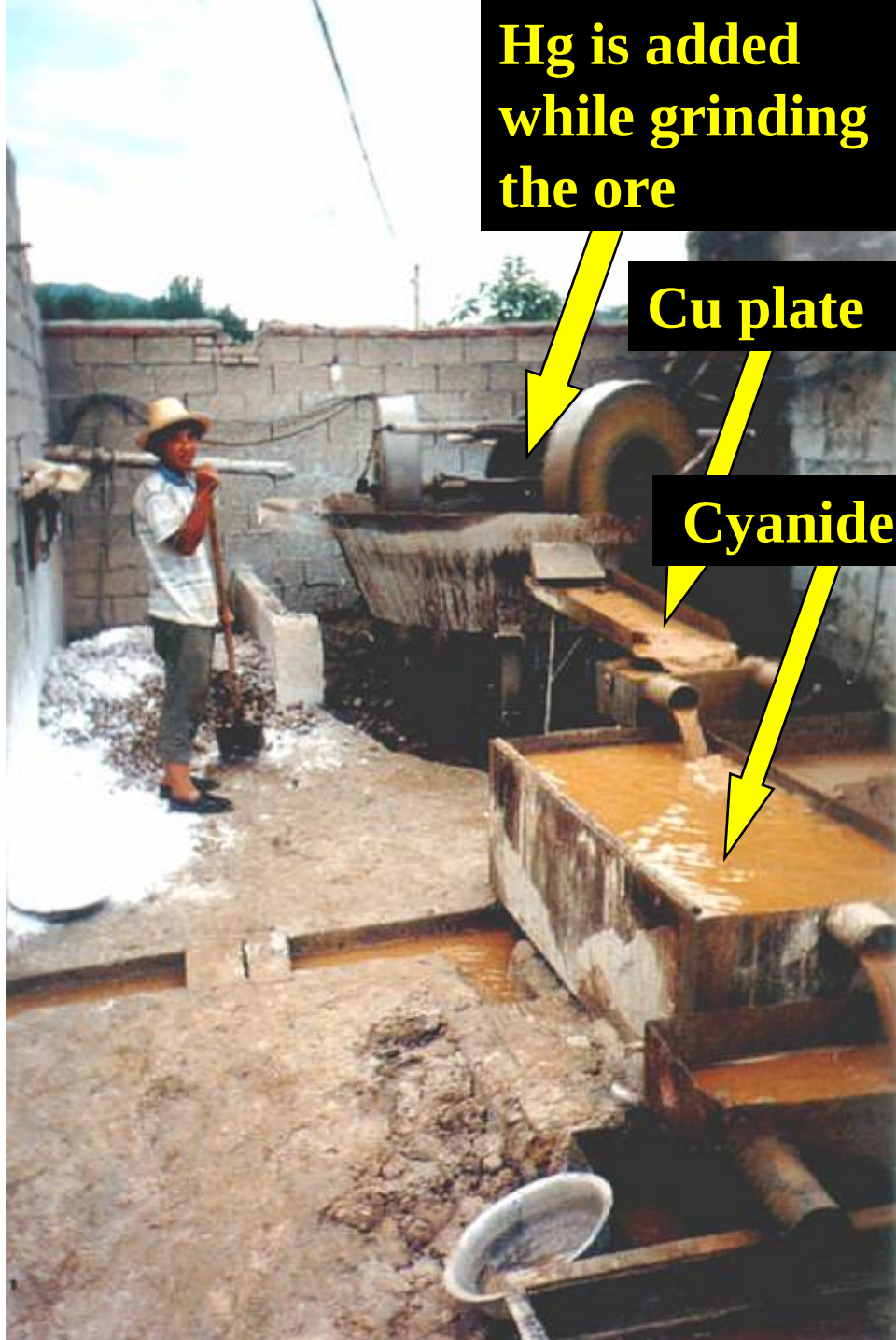


Photo AJ Gunson China, 2002

Why is CN being used?

- It gets the most gold
- It is what most large companies use
- Developing safe CN use for small scale operations is needed because of this reality
- Using mercury first for “quick cash” must be stopped through awareness campaigns
- Miners actually lose money doing this

Cyanidation of Hg-contaminated tailings reworking old tailings – releasing old mercury

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

Zimbabwe, 2004

Health and Environmental Impacts

- Symptoms of mercury intoxication are widespread,
- Levels of intoxication that exceed 50 times the WHO maximum public exposure limit were observed
- Neurological disturbances such as ataxia, tremors and coordination problems are common
- At one site, 70 percent of miners showed an unintentional tremor, a symptom of mercury-induced nervous system damage
- Inhalation of mercury during amalgam burning, often undertaken by women and children, represents a major health concern
- Breast milk of nursing mothers in mining communities is extremely high; infants are especially at risk

Hg occupational exposure is… obvious

Venezuela, 1995

Women and Children in ASM

- Increasing

Women fishing in abandoned mines!

Brazil, Tapajos Basin

Manual Amalgamation

Tanzania, 2005

The “easy” work

- Amalgamation is physically easy but highly toxic

Exposure to fumes

- Gold shop residences

Indonesia, 2006

Women Miners

Sudan, 2004

Children Miners

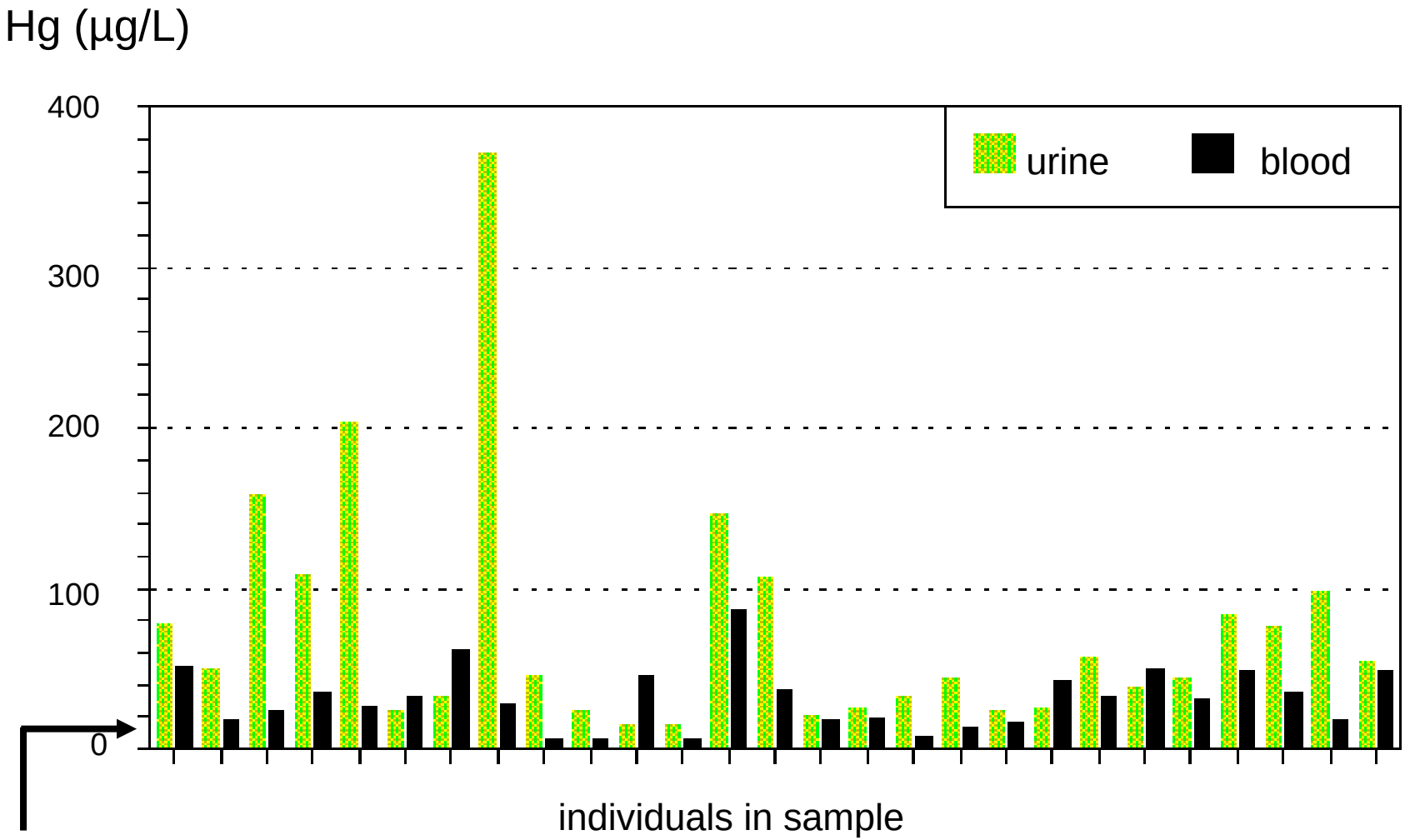
Venezuela, 1995

Laos PDR, 2001

Families of Miners

Laos, 2003

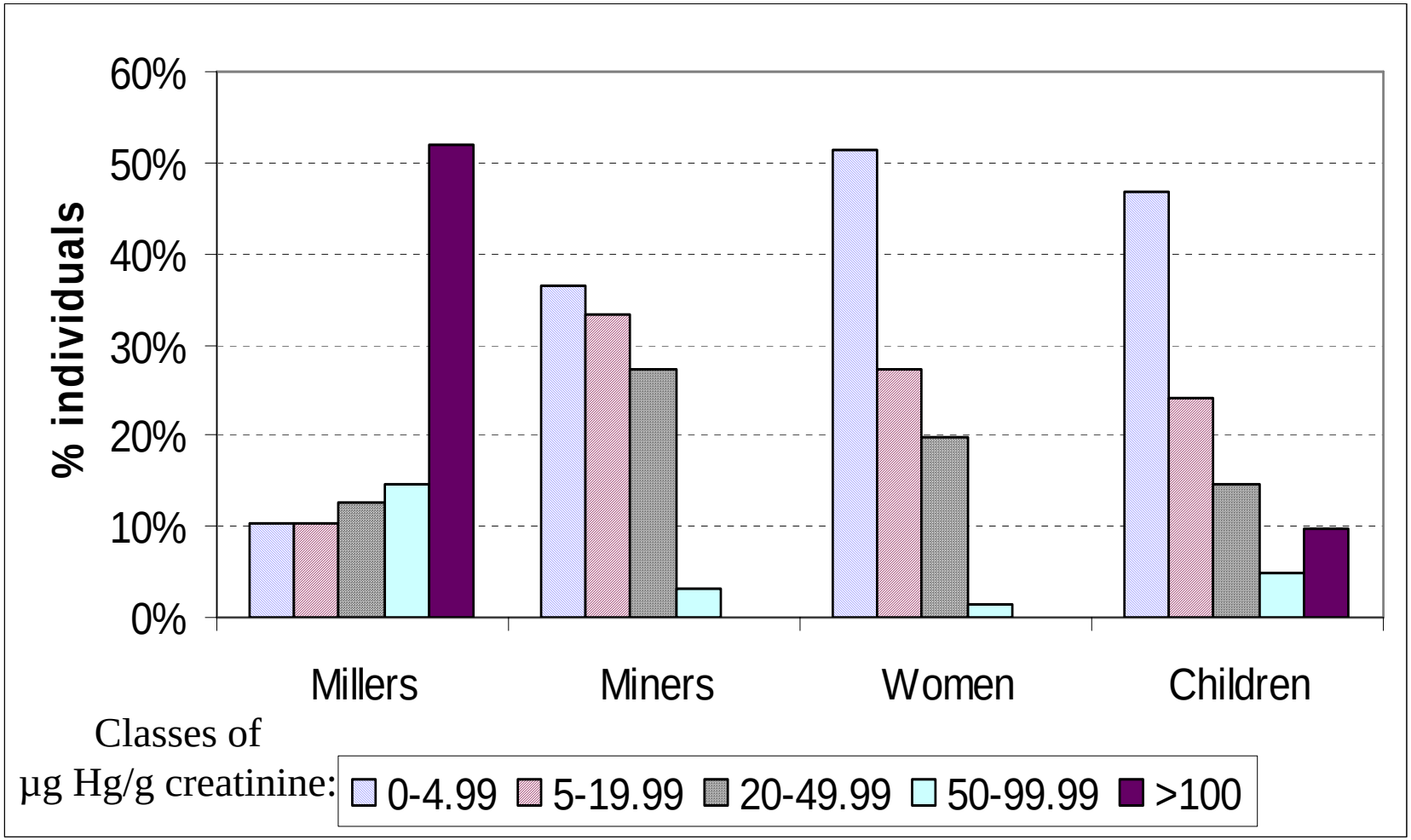
Mercury in Miners Burning Amalgam



Normal level <5 µg/L

Health Assessment

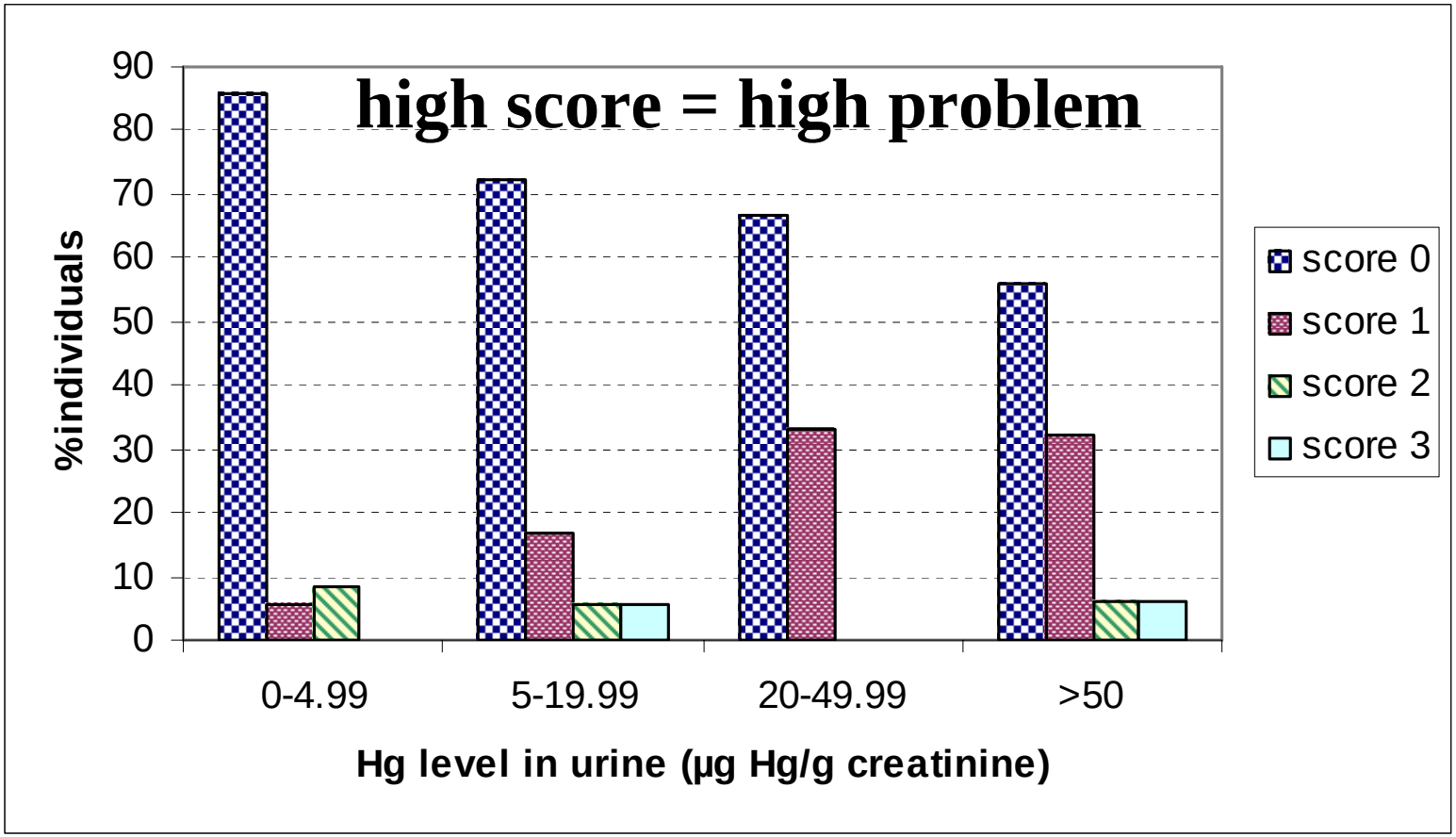
(Venezuela, 2003 - Urine Values)



Just urine analysis is not sufficient to characterize Hg intoxication

Relationship between Hg level in Urine and Score of the Episodic Memory Test (Venezuela Dec 2003)

78% miners with alteration of psychomotor functions



Trade: mercury doesn't grow on trees, it is exported and imported

- Mercury is readily available in most countries
- Enters developing countries legally, often for dental use
- The majority ends up being used in ASM
- Using import statistics for the 6 GMP pilot countries and neighbours GMP has determined:
- in 2005, Kenya imported 14 tonnes of mercury from Germany, followed by Georgia (9.5 tonnes) and Japan (4.1 tonnes)…
- See www.globalmercuryproject.org for more

Trade Conclusions

- It is unlikely that import statistics adequately capture the cross-border trafficking of mercury and the extent of diversion from legal sectors
- Regulating imports is more difficult than regulating exports from developed countries
- **Export bans will more effectively control mercury trade**

Four keys to reduction of mercury use in ASM

1. Introducing improved mining practices, including the elimination of whole ore amalgamation and open-air amalgam burning;
2. Introducing Hg free processing where viable;
3. An increased price for mercury – brought about through export bans – in order to encourage increased efficiency of use and transition to alternative technologies;
4. Awareness campaigns, policy and governance reforms, and community economic diversification

Retorts

Replacing Amalgamation of the Whole Ore

Indonesia, 2002

Recovery = Gold in Concentrate x 100

Gold in Ore

- In Indonesia: instead of amalgamating the whole ore we are using cyanidation in the ball or rod mill
- Preliminary results:
- 52% Au recovery in 30 min. grinding, 6 hours of cyanidation
- When using gravity only or magnetic sluice: only 7% recovery

Introducing Mercury Free Methods…

Good Practice

Mozambique, 2005

Policy and Governance

- GMP, working with governments and communities has developed and implemented various new policies such as:
  - mercury trade and management laws in Indonesia,
  - National mercury and mining labour laws in Zimbabwe,
  - policies to legalize and assist indigenous miners in Sudan,
  - and microfinance policy in Tanzania.

Strategic Plan on Policy and Governance

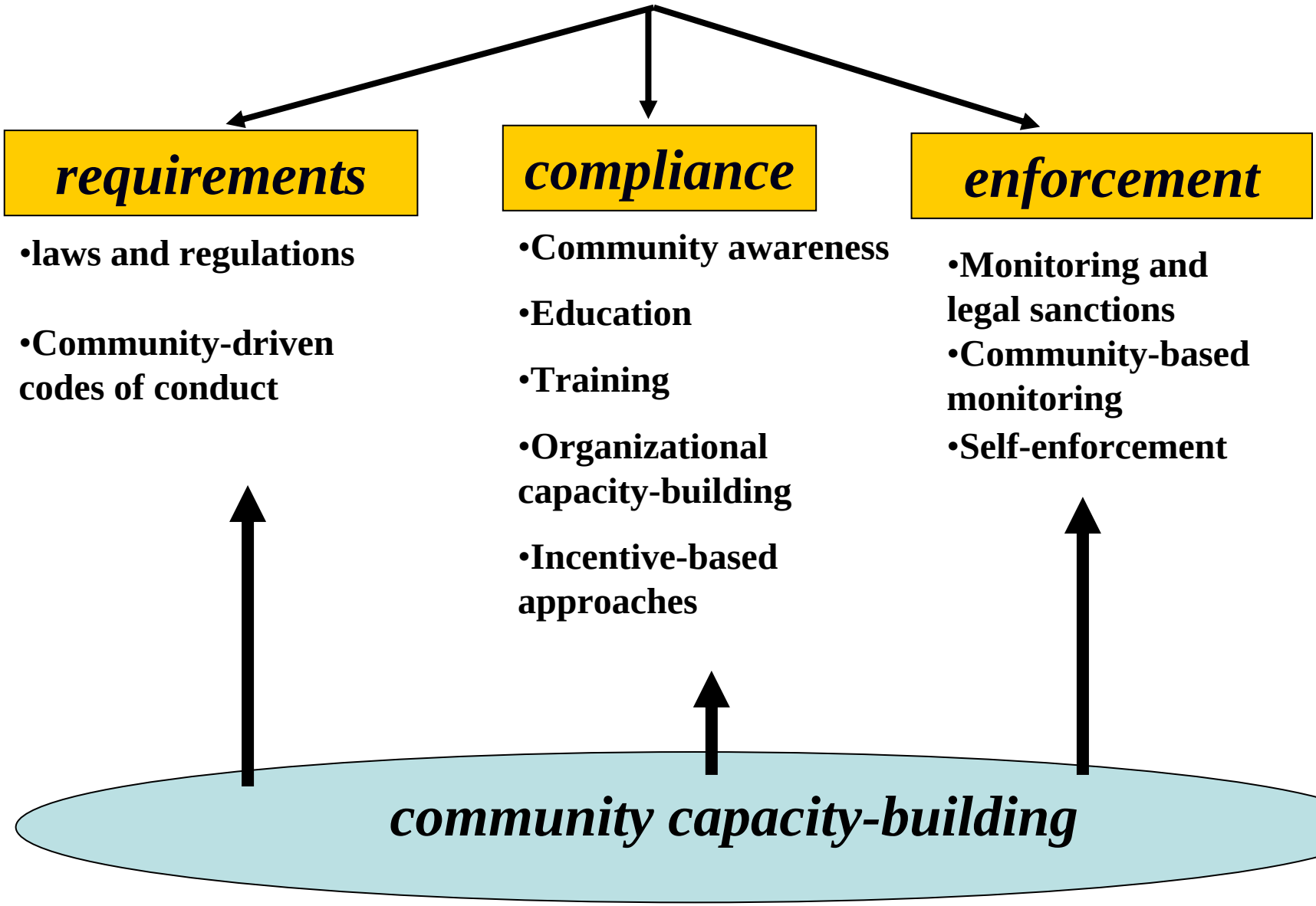
1. International Guidelines on Mercury Management
2. National Law on Mercury Management
3. Promotion of Awareness and Compliance
4. Capacity-Building and Technology Transfer
5. National Mercury Trade
6. Transboundary Mercury Trade
7. National ASM Sector Policy
8. International and Regional Law and Policy
9. Micro-Credit Initiative
10. ASM Cooperative Organization
11. Fair Trade Gold
12. Global Partnerships for Development

Policy review workshop with 30 Mines Officers

Implementation

- Bottom-up and top-down approaches by engaging and training:
- (i) local stake holders such as miners, local organisations and local governments, and
- (ii) regional and national governments, and international organisations and NGOs

Top-Down & Bottom-Up Policy Perspectives



Future steps

- Currently, pilot activities are focussed on developing capacity and new policy measures in six countries (Brazil, Indonesia, Laos, Sudan, Tanzania, and Zimbabwe)
- A next step is to develop regional ***centres of excellence*** that will act as a permanent resource for small scale miners over the long term

Many knowledge gaps remain

- **Quantities of Hg and Au**
- **Transport/Fate**
- **Methylation**
- **Retorts**
- **Fume Hoods**
- **Risk (Health & Safety)**
- **Monitoring**
- **Cyanide**
- **Prevention**
- **Remediation**
- **Alternatives**

- There is little high quality information or consensus on many of these
- **Action and improved understanding are needed urgently**
- **jointly and continuously**
- **continuous innovation**

Why is this information needed?

- Knowledge mobilizes decision makers at all levels
  - Miners
  - Local government
  - Local people
  - Regional government
  - National government
  - Private sector
  - General public
  - International bodies & awareness efforts
- All want good information

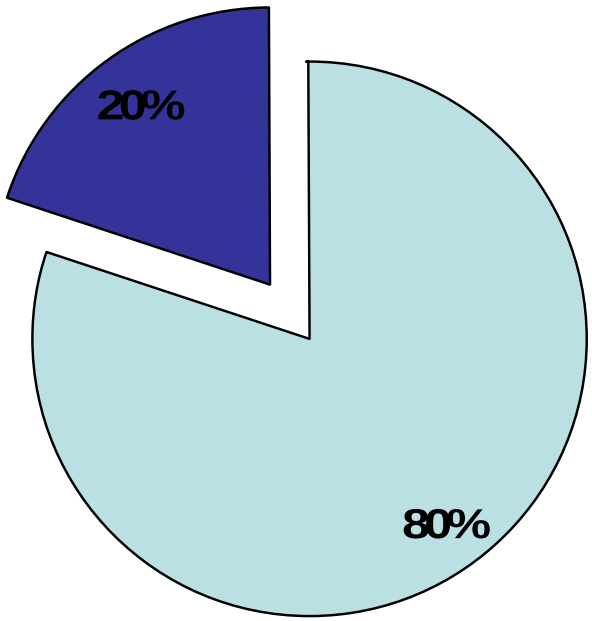
V. Big Knowledge Gap Alternatives

- Is there any economic activity that can replace or enhance gold based economy?
- Large scale mining?
- Coal?
- Aggregate?
- Landuse?
- Heavy mineral mining?
- Must add value to these, create markets
- Investment
- 280 million $ since 1989!

Goal – 50% in 10 years

- If the GMP approach is broadly embraced, we believe that at least a 50% reduction in mercury demand in small scale mining is attainable in 10 years time (by 2017)

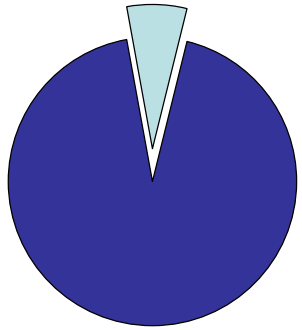
Current - 2007



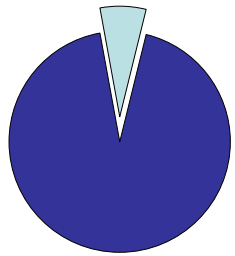
1000 Tonnes

2017

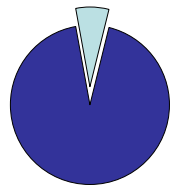
500 Tonnes: elimination of whole ore amalgamation



400 Tonnes: also use of retorts



200 Tonnes: also mercury-free alternatives



Conclusions

- GMP is currently a pilot program
- It is a community assistance model
- It is receiving widespread support
- However, only a fraction of the global ASM population has been touched
- Progress could evaporate without further efforts
- Further commitment is needed

Conclusions

- The 10-year goal of reducing mercury consumption in ASM by over 50% is ambitious but achievable
- The GMP calls on all nations to achieve the above goal by:
  - pledging commitments to programs to help build community capacities
  - reducing mercury supply through export controls and other mechanisms that encourage transitions to alternative technologies
- Importantly, it is unethical for the second to happen without the first
- Further information on the activities of the Global Mercury Project can be obtained at the project website: www.globalmercuryproject.org

Education is Everything

Sudan, 2004

But it works both ways

- Visit an ASM site near you soon!

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