



ICMGP 2024
CAPE TOWN • SOUTH AFRICA • 21 - 26 JULY

Obtaining Gold and Mercury Losses in an Artisanal Mining Site in Nigeria

Nnamdi C. Anene, Bashir Musa, Yunusa H.
Mohammed, Claudie Robert-Lemire, Cristopher
Yeomans, Marcello M. Veiga





Authors

- **Nnamdi C. Anene**, Dept of Artisanal and Small-scale Mining, Ministry of Solid Minerals Development, Abuja, Nigeria
- **Bashir Musa**, Miner, Zinariya Kyautar Allah Venture Uke Ltd, Uke, Nasarawa State, Nigeria.
- **Yunusa H. Mohammed**, Dept of Artisanal and Small-scale Mining, Ministry of Solid Minerals Development, Abuja, Nigeria
- **Claudie Robert-Lemire**, Alinea International, Calgary, Canada
- **Cristopher Yeomans**, Alinea International, Calgary, Canada
- **Marcello M. Veiga**, Norman B. Keevil Institute of Mining Engineering, University of British Columbia, Vancouver, Canada and Alinea International



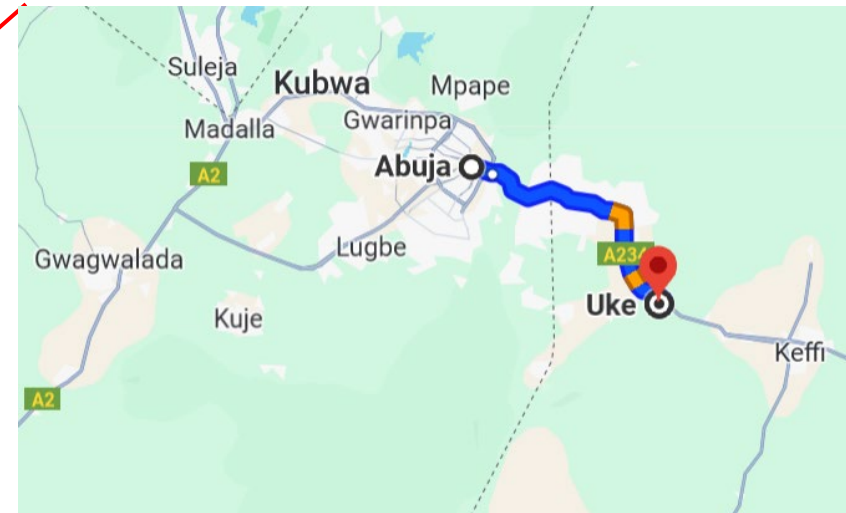
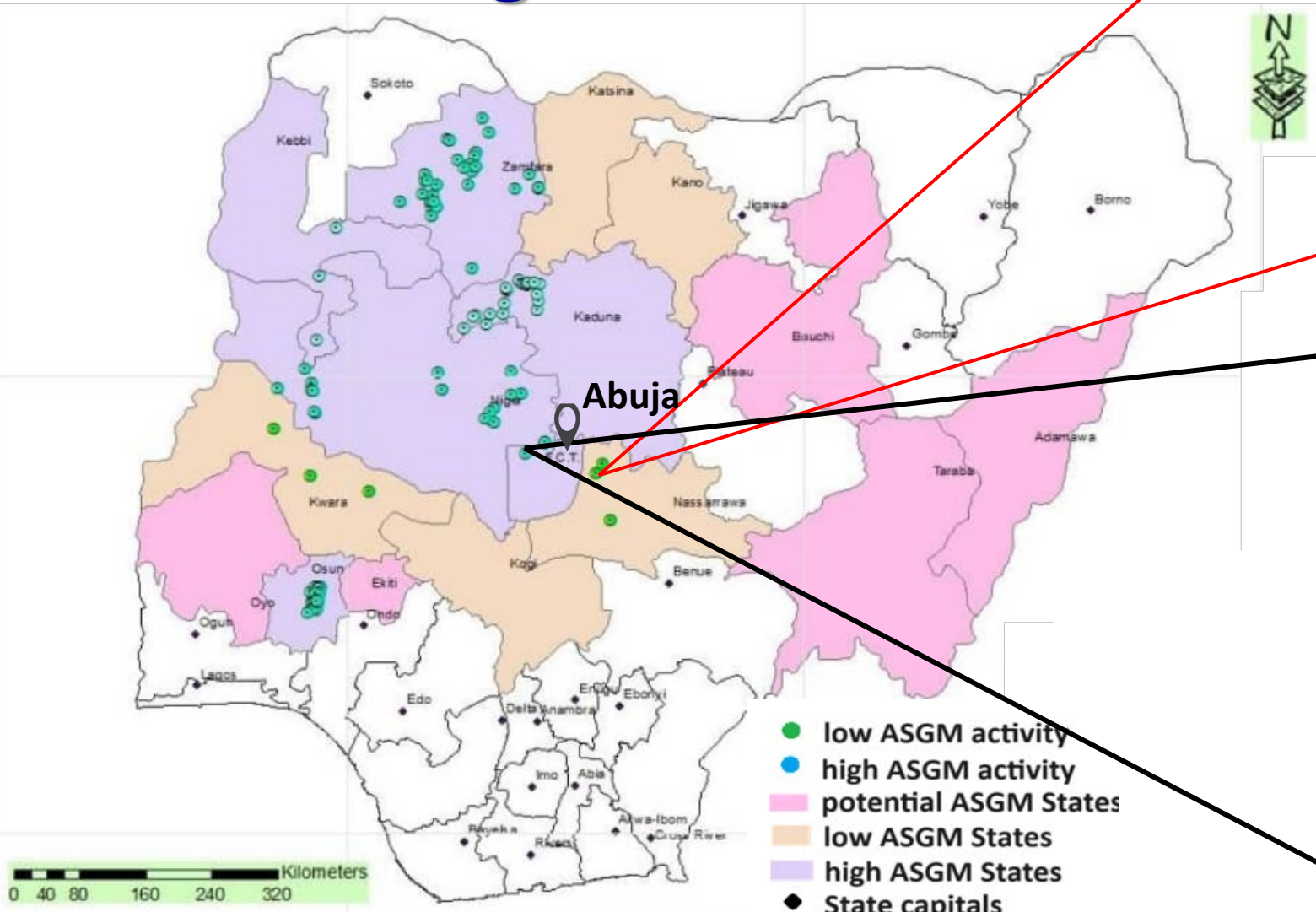


- **Alinea International is the implementing the TAP-EDM projects**
 - **Canada's Technical Assistance Partnership –TAP**
 - **Expert Deployment Mechanism - EDM**
- **This initiative brings experts from a diversity of sectors, backgrounds, genders, cultural identities and regions across Canada to share their expertise with partner countries around the world.**
- **TAP-EDM is working in 36 countries**
- **Funded by Global Affairs Canada**
- **This talk is about the Project in Nigeria**

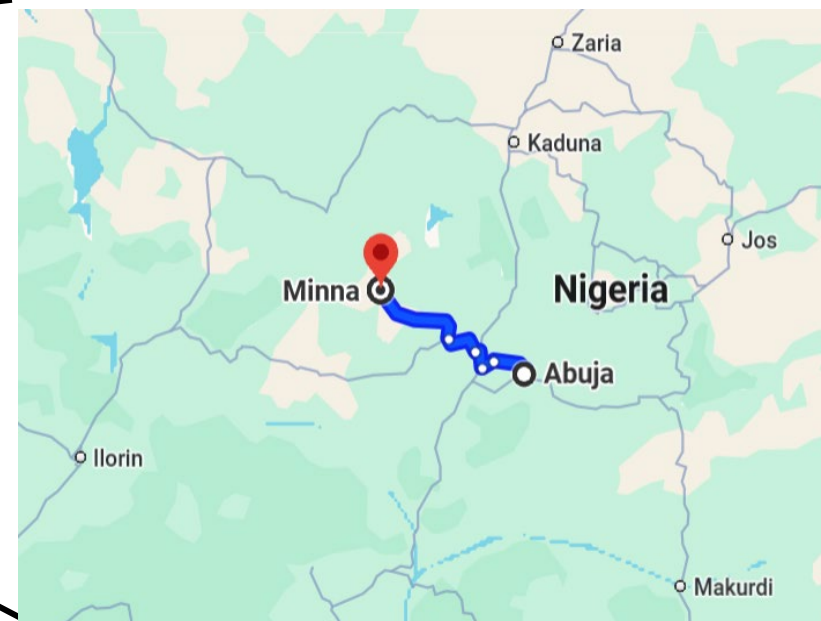
Artisanal Mining in Nigeria

- **500,000 to 1 million artisanal gold miners**
- **Numbers of gold production from artisanal miners are fuzzy: 6 - 16 t of Au/a**
- **UN estimate 20 to 40 t/a of mercury being released to the environment**
- **Minna has 5000 miners**
- **Uke has ~4000 miners**
- **In both sites, 40% women**

Studied Artisanal Mining Sites



34 km SE of Abuja



156 km NW of Abuja

Conclusion

Before suggesting any technical change in the gold processing, it is important to find out the current % Gold Recovery and % Hg Loss

Mining Primary Ores, Uke

- **Underground mine (20 m deep) operated by a group of 50 to 60 miners that blast, muck the ore and pull buckets to the surface.**
- **The ore is then carried manually to a truck that transports it to processing centers 4 km away**



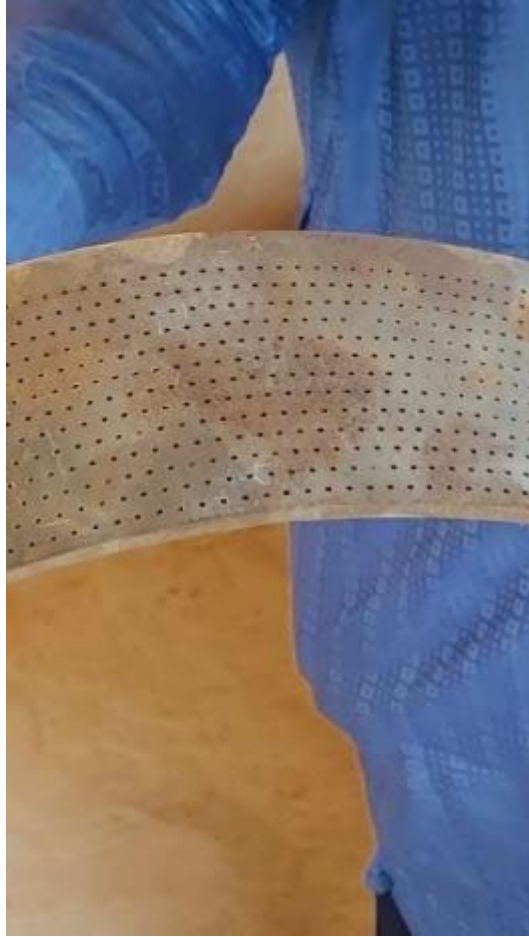
Uke Processing Centers

- Miners bring the ores to processing centers and pay US\$ 3.2 per 120-140 kg bag of ore to be crushed and ground **below 1 mm**



Hammer mill

Uke Processing Centers



1 mm holes



Ground Ore Goes to Sluice Boxes

The Processing Center charges US\$ 0.64 per bag of ore to process the ground ore in sluice boxes



Ground Ore Goes to Sluice Boxes

- Sluices with angle of 15°
- Wool carpets
- Manually fed...little water
- Pulp density = 40% solids (too high!!!)



Concentrate is Amalgamated Manually

- **Concentrate is removed after processing 10 to 20 bags (1300 to 2600 kg)**
- **Miners must buy their own mercury to amalgamate the gravity concentrates**



Nigeria

Mercury is Freely Sold at the Site



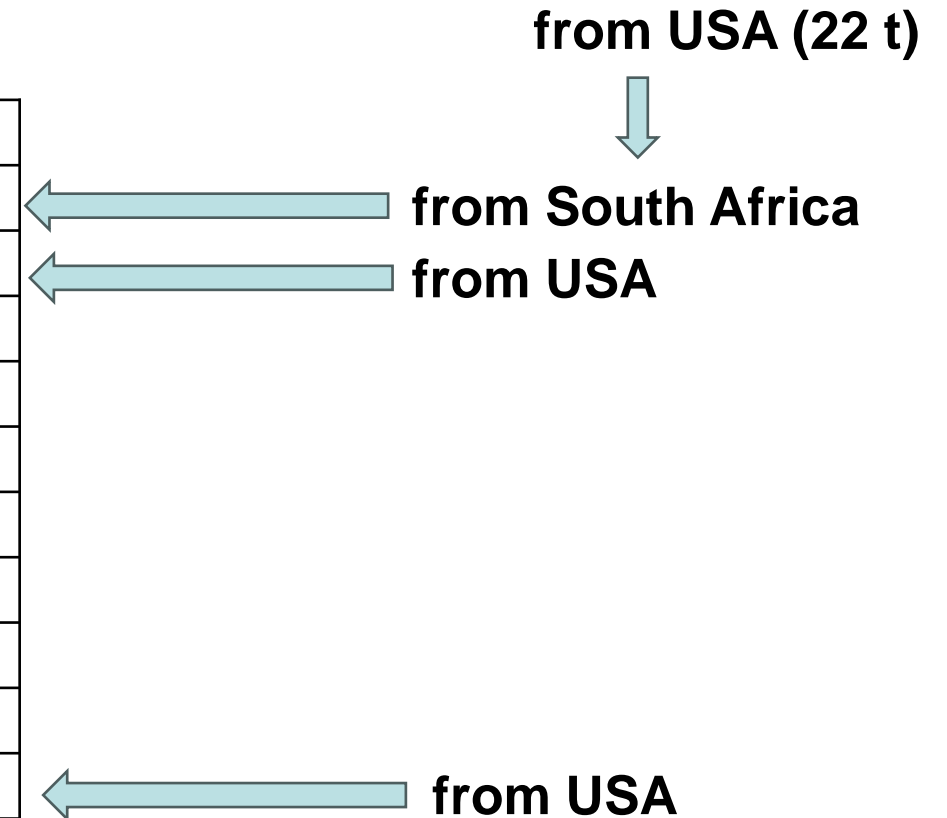
- Price of mercury is US\$ 123 per kg
- Nigeria ratified the Minamata Convention on Feb 1st, 2028

Mercury Imported by Nigeria

Year	Hg (kg)
2004	n.d.
2005	n.d.
2006	n.d.
2007	0
2008	0
2009	n.d.
2010	n.d.
2011	n.d.
2012	789

↑
from India

Year	Hg (kg)
2013	28,255
2014	655
2015	n.d.
2016	3
2017	n.d.
2018	n.d.
2019	n.d.
2020	n.d.
2021	16
2022	103



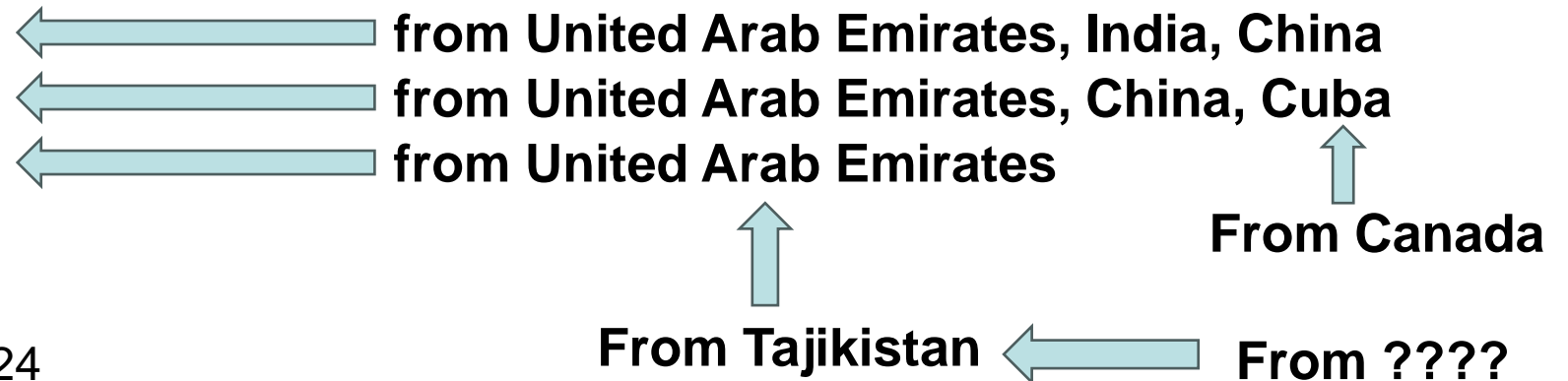
Source: UN COMTRADE, 2024

Mercury Imported by Togo

Year	Hg (kg)
2013	21,997
2014	40,982
2015	43,750
2016	42,747
2017	61,185
2018	49,886
2019	39,260
2020	36,821
2021	93,740
2022	159,220
2023	485,940

Togo signed the Minamata Convention on Oct 10, 2013 and ratified on Feb 03, 2017.

Togo “produces” 20 t/a of Gold.



Source: UN COMTRADE, 2024

Amalgam is Decomposed

- Amalgam is burned in bonfires
- Kids blowing the fire are directly **exposed to mercury vapor**



Gold Balance in Uke and Minna, Nigeria



Conduct this process in **5 operations in Uke** and **4 in Minna** for 4 hours/each, every 15 min. to obtain composite samples of feed and tailings

All analyzed in triplicate



Sample from feed

Sample from tailing

Results Gold Grades

Mine Site	Feed (ppm Au) Fire Assay 50g	STD	Tailings (ppm Au) Fire Assay 50g	STD	Au Rec. (%)	STD
UKE	3.80	0.74	2.69	0.44	29.20	6.63
MINNA	1.95	0.84	1.13	0.37	36.80	20.80



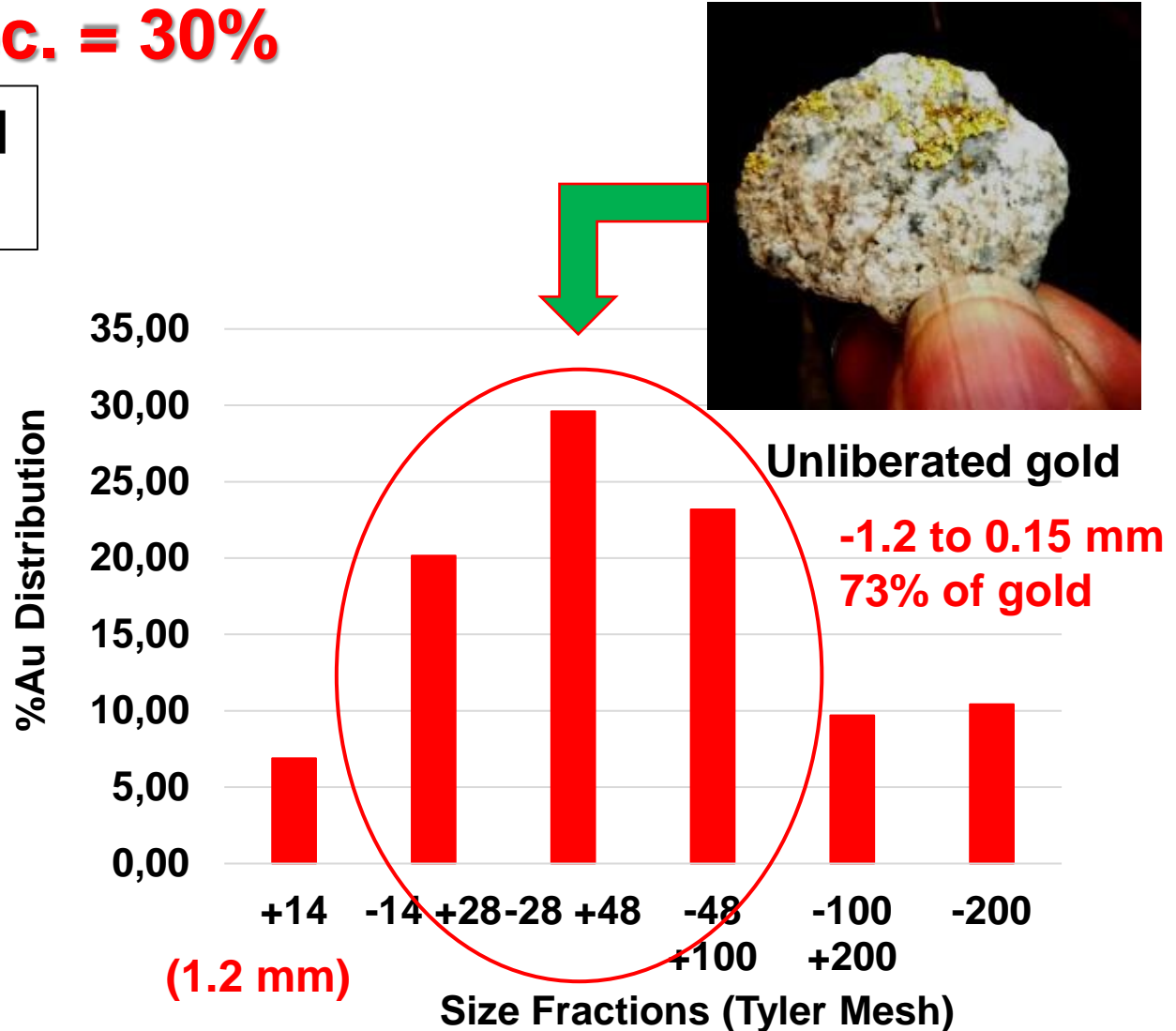
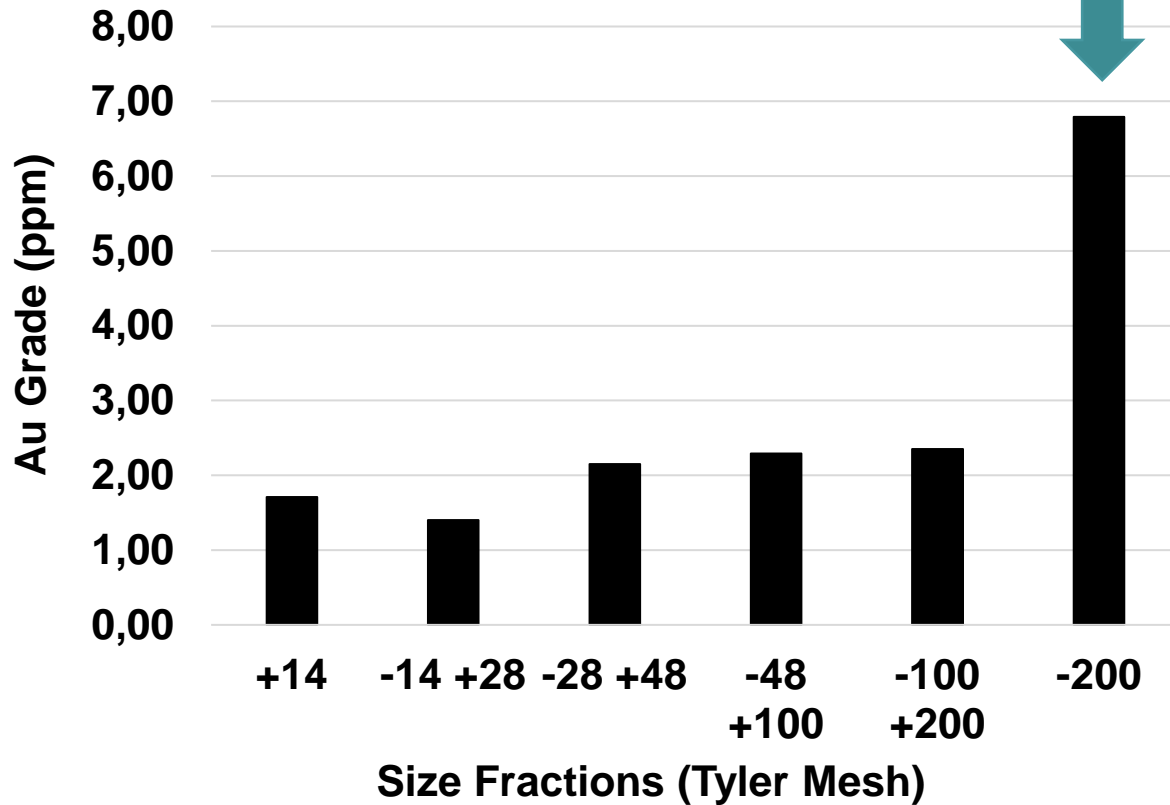
63 to 70% of Gold Lost in the concentration process

Tailings from Uke, Nigeria (Operation #5)

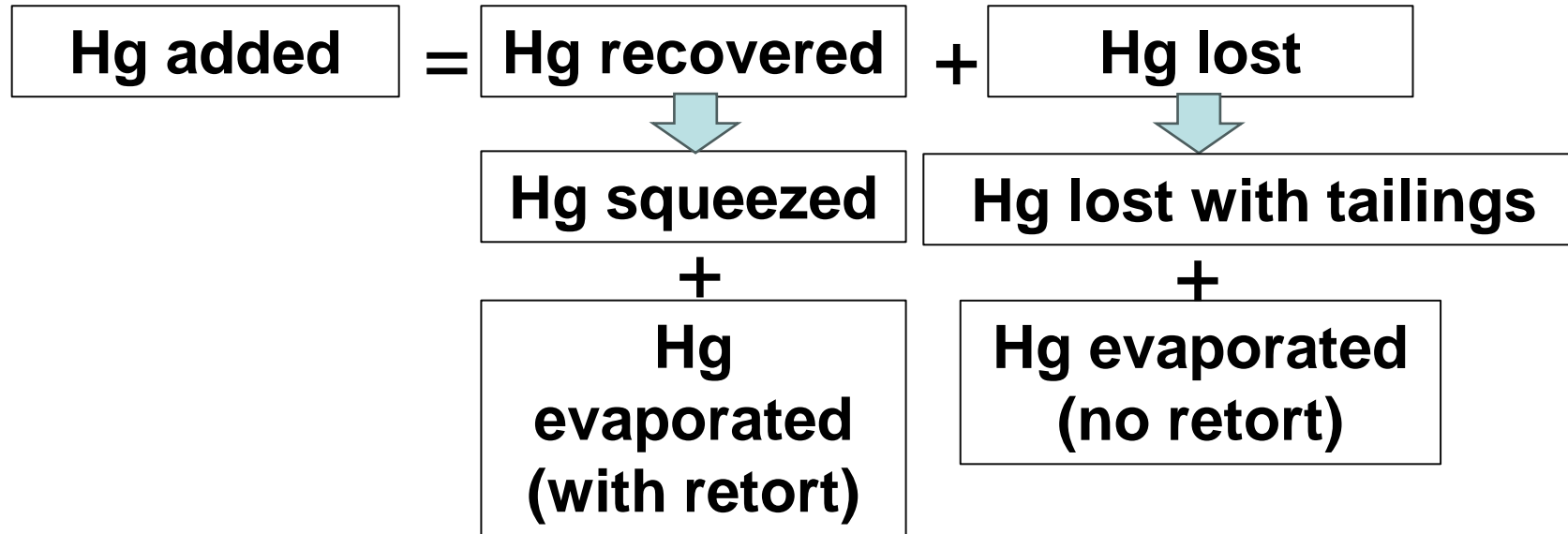
Tail = 2.06 ppm Au

Au Rec. = 30%

**Gold is Fine and probably unliberated
Miners could not recover it**



Mercury Balance (using only a portable scale)



Hg added = weight at the beginning

Hg squeezed = weight after manual filtration

Hg evaporated (with retort or not) = amalgam weight before burning – doré weight

Hg lost with tailings = Hg added – Hg recovered – Hg evaporated (with or without retort)

Hg recovered = Hg squeezed + Hg evaporated (with retort)

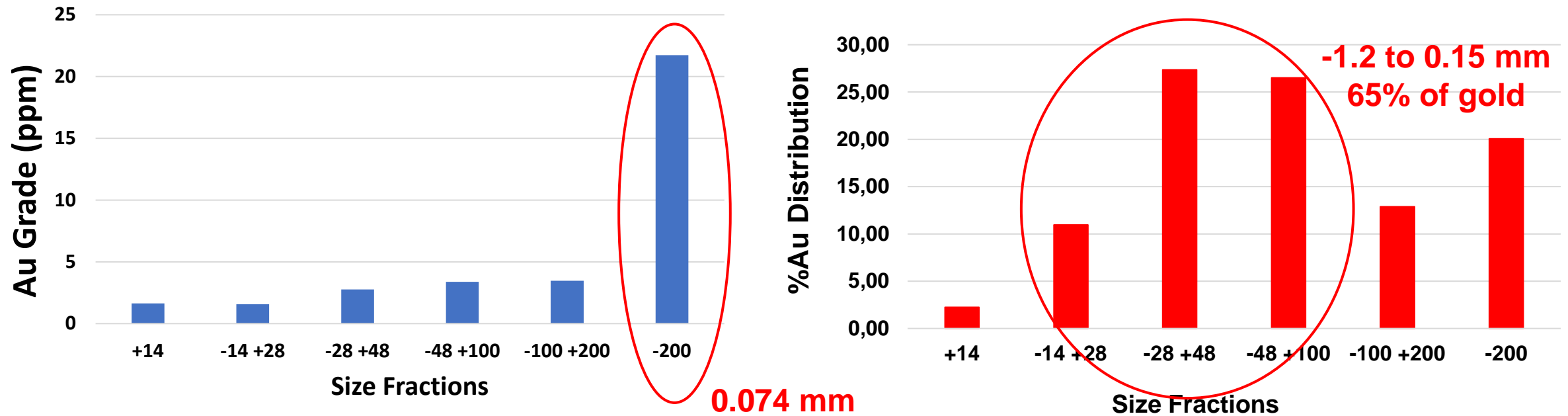
Hg recovered with retort = Hg recovered – Hg squeezed

Mercury Balance in Uke (amalgamation of concentrates, no retort)

Point Sampled	Hg added (g)	Hg recovered by filtration (g)	Hg lost by evaporation (g)	Hg lost with tailings (g)	%Hg Lost by Evaporation	%Hg Lost with Tailings	%Hg Recovered	Amalgam Obtained (g)	Doré Obtained (g)	%Hg Evaporated from Amalgam	Hg _{LOST} : Au _{PRODUCED}	%Total Hg Lost
Point 1	8.78	4.83	0.25	3.70	2.85	42.14	55.01	0.47	0.22	53.19	17.95	44.99
Point 2	152.00	33.00	44.00	75.00	28.95	49.34	21.71	75.00	31.00	58.67	3.84	78.29
Point 3	33.00	13.00	5.00	15.00	15.15	45.45	39.39	7.00	2.00	71.43	10.00	60.61
Point 4	25.00	19.00	1.19	4.81	4.76	19.24	76.00	2.00	0.81	59.50	7.41	24.00
Point 4	7.50	4.99	0.50	2.01	6.67	26.80	66.53	4.10	3.60	12.20	0.70	33.47
Point 5	2.40	1.26	1.13	0.01	47.08	0.42	52.50	2.03	0.90	55.67	1.27	47.50
Point 6	9.46	6.47	0.30	2.69	3.17	28.44	68.39	3.10	2.80	9.68	1.07	31.61
Point 1	8.48	2.96	0.77	4.75	9.08	56.01	34.91	1.60	0.83	48.13	6.65	65.09
Point 3	9.45	6.32	0.40	2.73	4.23	28.89	66.88	2.20	1.80	18.18	1.74	33.12
Point 8	6.58	4.45	1.90	0.23	28.88	3.50	67.63	5.60	3.70	33.93	0.58	32.37
Point 9	3.12	1.25	1.07	0.80	34.29	25.64	40.06	3.09	2.02	34.63	0.93	59.94
Point 10	7.13	4.87	1.10	1.16	15.43	16.27	68.30	4.90	3.80	22.45	0.59	31.70
Point 11	11.38	8.18	1.48	1.72	13.01	15.11	71.88	7.08	5.60	20.90	0.57	28.12
Point 12	2.95	1.73	0.23	0.99	7.80	33.56	58.64	1.03	0.80	22.33	1.53	41.36
Point 13	8.56	6.42	1.88	0.26	21.96	3.04	75.00	8.08	6.20	23.27	0.35	25.00
Point 14	5.63	4.47	0.40	0.76	7.10	13.50	79.40	1.80	1.40	22.22	0.83	20.60
Point 16	4.81	2.31	0.86	1.64	17.88	34.10	48.02	3.66	2.80	23.50	0.89	51.98
AVERAGE	18.01	7.38	3.67	6.96	15.78	25.97	58.25	7.81	4.13	34.70	3.35	41.75
STDev	35.41	7.96	10.45	17.88	12.66	16.44	16.54	17.46	7.13	19.06	4.73	16.54

Evaluating Amalgamation of Concentrates Uke, Nigeria

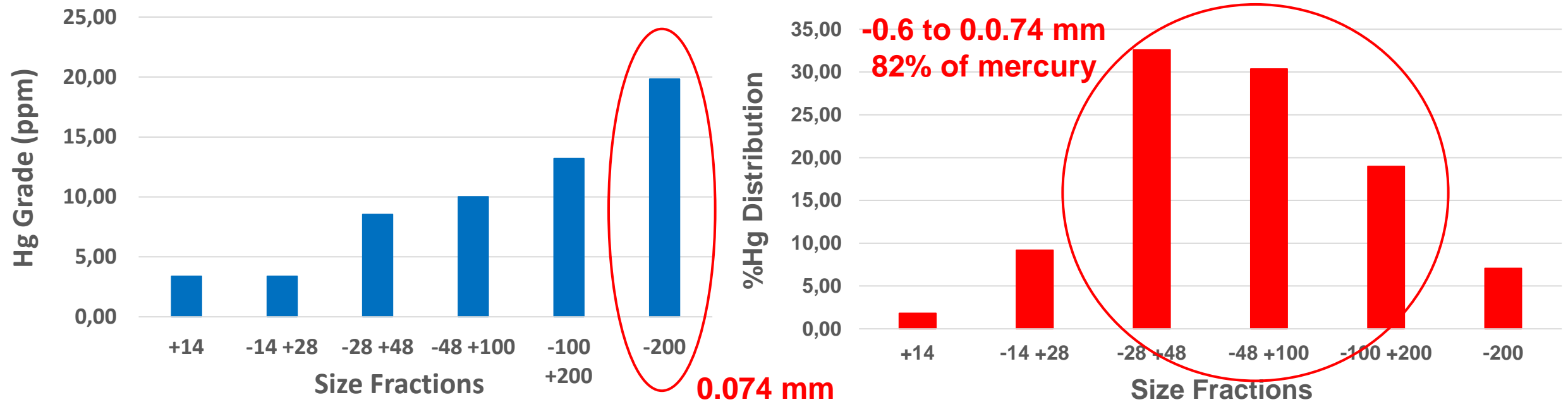
- **Gold** was analyzed in an **amalgamation tailing** sized fractions



- % Gold lost ~50%. Mercury cannot trap fine gold
- Mercury cannot trap unliberated gold in the relative coarse fractions...65% of gold is lost in -1.2 + 0.15 mm

Evaluating Amalgamation of Concentrates Uke, Nigeria

- **Mercury** was also analyzed in this **amalgamation tailing** fractions



- **Mercury is lost in the fines (pulverized Hg) but the main portion, 82% in the relative coarse fraction (bad panning)**

Conclusion

- Miners **lose 63-70% of the gold** in the concentration and probably **more than 50% in the amalgamation**
- Gold is very fine (unliberated from gangue minerals)
- They should grind finer (0.2 mm) and use zigzag sluices or centrifuges



Conclusion

- Miners are losing **16% of Hg** when burn amalgams in bonfires and **26% of Hg** with tailings = **42% Hg lost**
- Using retorts and activated Hg, they will lose less
- If the amalgamation recovers 50% of the gold (only liberated particles) and the concentration 30%, then total Gold Recovery ~15% or ~**85% of gold is lost**
- The $\text{Hg}_{\text{Lost}}:\text{Au}_{\text{Produced}} = 3.35$ is **TOO HIGH!!!**
- This ratio should be = 1

Returning Results to Miners



Returning Results to Miners



Acknowledgements

- **Thanks to Mr. Akintunde Akinkunle, Mr Olabisi Mojinyinola, Mr Chike Ajaero, Mr. John Kullokom, Mr. Adeyemi Moroofo, Mr Ugochukwu Akeru, Ms Halima Ibrahim, Mr Etido Umoakpan and Ms Hasana Sha'aba from the Dept of Artisanal Mining of MSDM**
- **Thanks to GARDA Mr. Lawal Adetuniji, Mr Musa Aliyi and others**
- **Thanks to the Alinea staff for all support**
- **We also acknowledge many other miners from Uke who assisted us in the metallurgical balances**



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Thank You

