Geoforensic Passport
Applications

LBMA
Assaying & Refining Conference 2023

Barbara Beck, University of Lausanne
Patrice Kiener, InModelia, Paris

London, March 14, 2023

UNIL | Université de Lausanne

Our goal

➢ For refiners in Switzerland, to reliably confirm the supplier's declared origin for every doré

Our solution

GEOFORENSIC PASSPORT

Our approach

➢ **Tool based on geochemical and geostatistical methods**
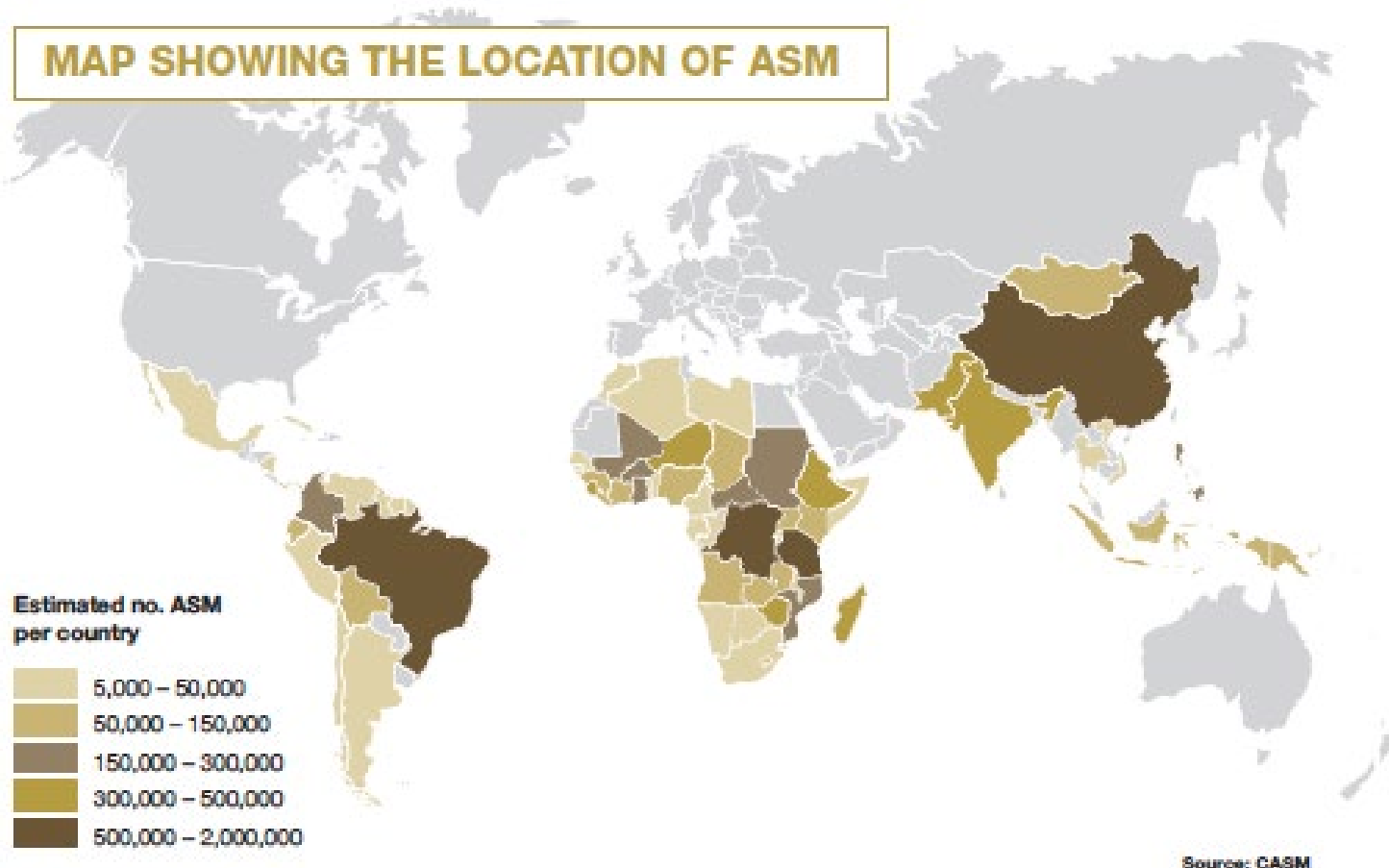
Technical feasibility

➢ **Confirmation of origin** is possible using a scientific, multistep method

➢ Even small percentage mixtures (< 10%) can be detected

➢ **Link from mine to refinery**

Refiner's requirements

• Quick method using **existing analytical equipment**

• Integration in existing flows: systematic analysis & **low cost**

UNIL | Université de Lausanne

ASM is a global phenomenon occurring in at least 70 countries in Africa, Asia and Latin America.[22]

MAP SHOWING THE LOCATION OF ASM

Estimated no. ASM per country

- 5,000 – 50,000
- 50,000 – 150,000
- 150,000 – 300,000
- 300,000 – 500,000
- 500,000 – 2,000,000

Source: CASM

In Burkina Faso in 2001:

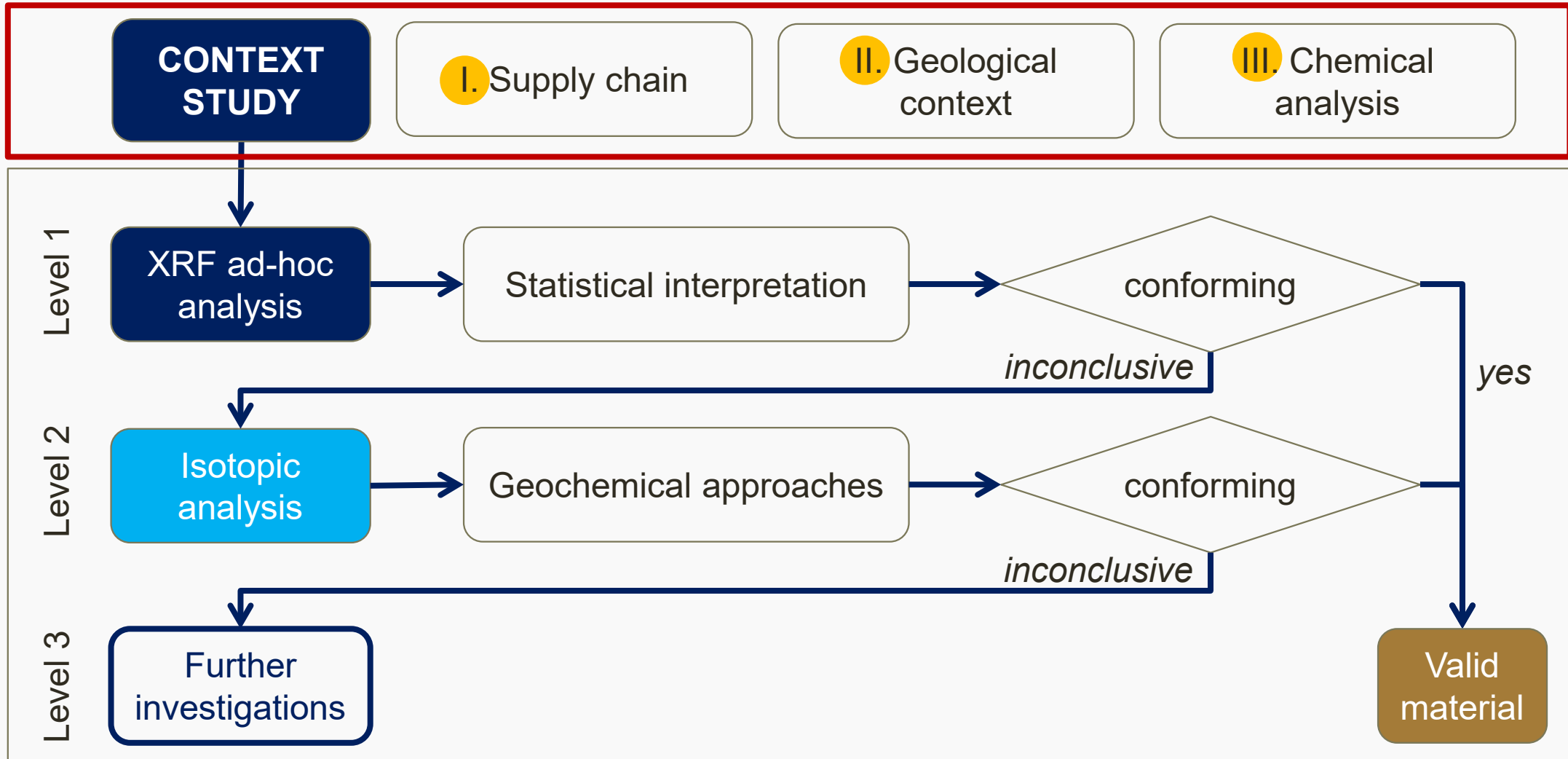12 **industrial mines**
Employing 7 000 people

200 **artisanal mines**
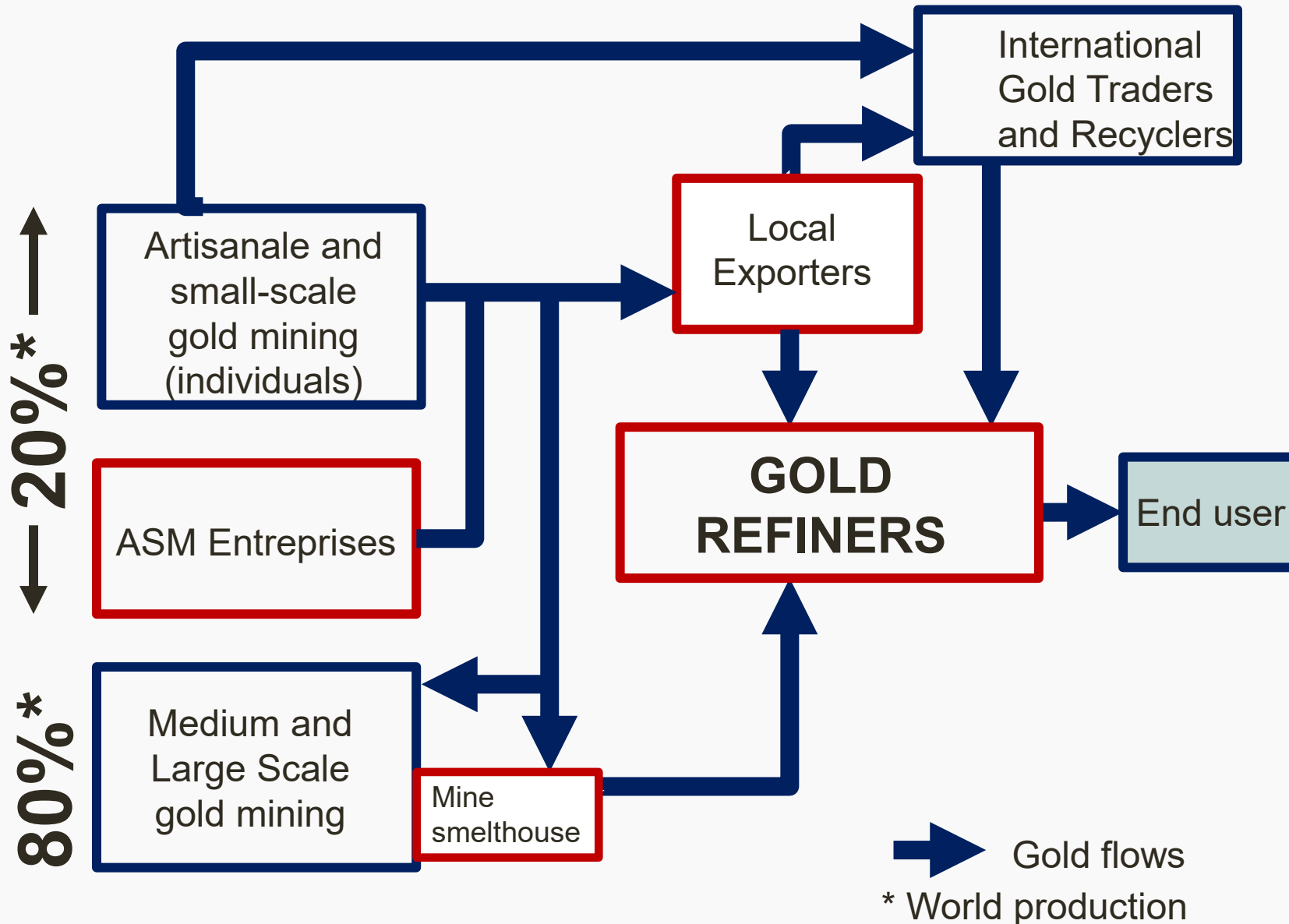(ASM)
1 – 1.2 million people
depend on this activity

Integrating artisanal mines into a legal supply chain

How the geoforensic passport can help to integrate ASM into a legal supply chain?
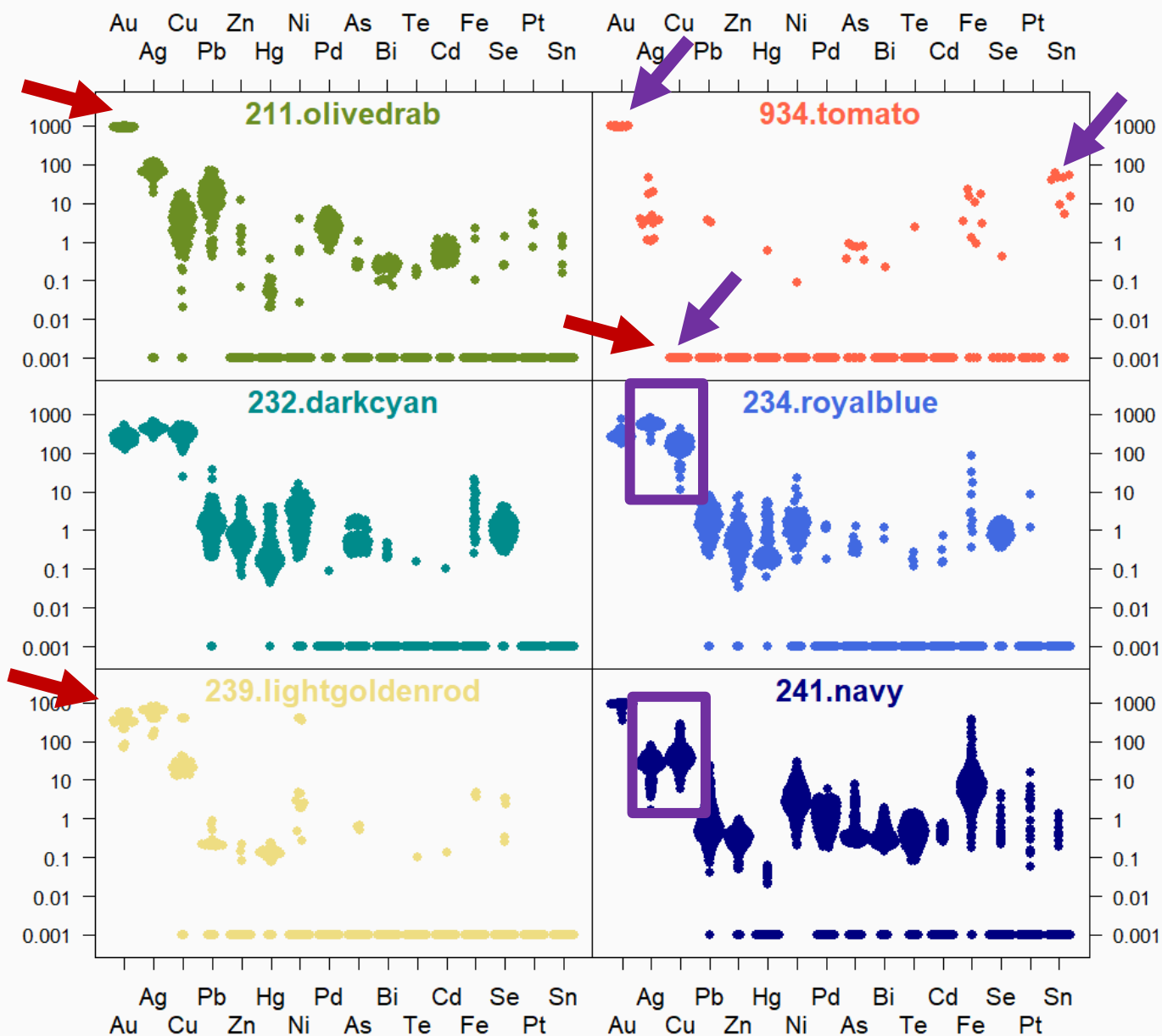
Our approach

Structure of the supply chain

➢ General organisation

➢ Groups ↔ isolated exploitations

➢ Formalized ↔ non formalized regions

➢ **Bottlenecks of the supply chain**

OECD Due Diligence Guidance Minerals 2016, modified

➤ What are the possible different geological contexts

➤ What is the chemical variability of the doré bars related to the geological context

Beeswarms
- 6 suppliers
- Doré samples
- 16 elements of 20
- Logarithmic scale

➤ The type of sample analysed (**gold, ore**)

➤ The analytical protocol used

➤ Is it possible to set up or extend an analytical protocol

➤ Who collects the data and how often

➤ Is **historical analytical data** available (from the last few month)

➤ What are the difficulties of the data set

Example: case study
❖ Semi-industrial processing plant: 2 semi-industrial and 385 artisanal mines
❖ 2 data sets:
- (1) doré bars
- (2) minerals

The data:

- 54 doré bars
- 20 elements analysed by ED-XRF
- Example of a data set:

| [‰]	As	Co	Au	Te	Pt	Bi	Fe	Ni	Ag	Pb	Zn	Pd	Cu
A	nd	nd	728.7	nd	nd	nd	nd	5.5	186.6	nd	nd	2.5	72.3
B	nd	nd	493.4	nd	nd	nd	nd	nd	497.0	nd	nd	nd	8.0
C	7.4	nd	842.8	nd	nd	nd	8.7	8.2	71.7	nd	nd	3.4	55.7
D	nd	nd	728.7	nd	nd	nd	nd	5.5	186.6	nd	nd	2.5	72.3
E	6.6	nd	605.4	1.0	nd	5.2	nd	nd	176.1	13.6	0.6	2.3	187.1
F	nd	nd	188.8	nd	nd	nd	nd	0.1	797.0	2.9	4.9	nd	5.9

Contextual issues:

- Mix of several sources in varying proportions

Statistical issues:

- Very high detection limits
- Many values not determined (nd: 60% of the total data, 80% of trace elements)
- Large gap between maximum (around 1000 ‰) and minimum (< 1 ‰) values

Photo: S. Ansermet
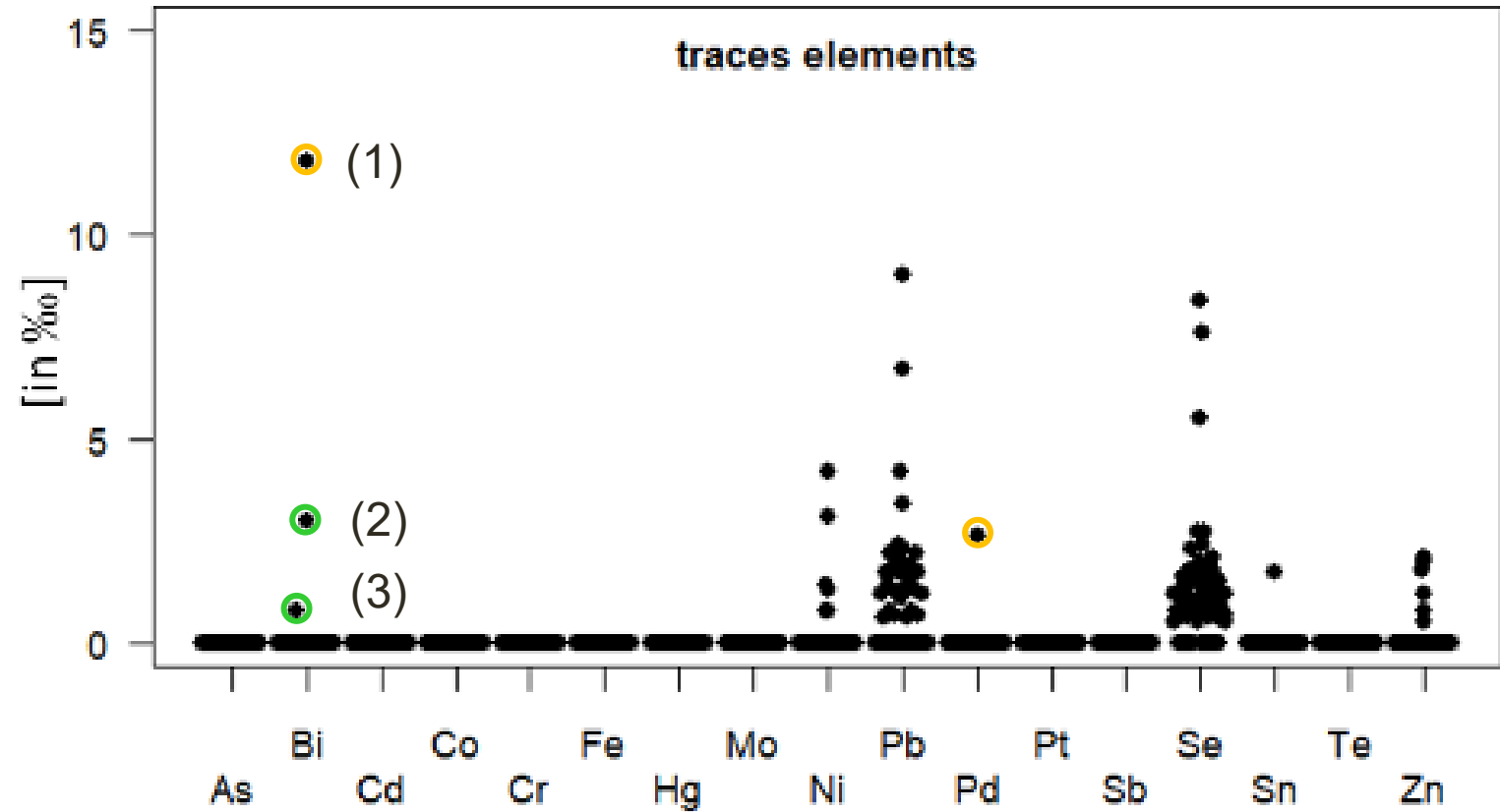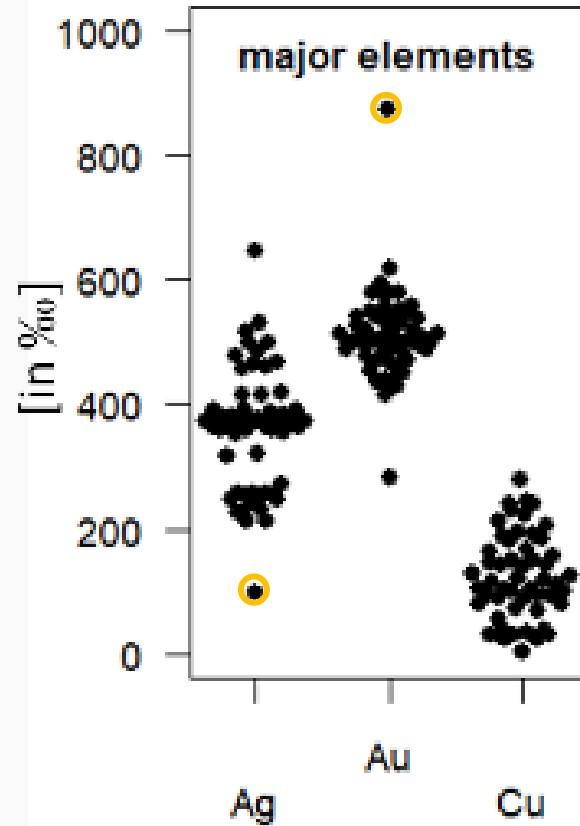
Beeswarms
- Doré samples
- 1 processing plant supplied by almost 400 artisanal mines
- 20 elements of 20

Observations
- 🟠 Outlier?
- 🟢 2 other samples with similar correlation for Pb, Bi, Ag, Au and Cu common source that makes up the doré bars to
  (1) 80-100%   (2) 20-25%   and   (3) 5-7%
- ➡ Regular supply

The data:

- ~ 1300 mineral samples from about 40 suppliers

- 4 elements (Au, Ag, Cu, As) analysed by AAS (Atomic Absorption Spectrometry) on arrival at the processing plant.

- Example of a dataset:

Lote	Au (gpt)	Ag (gpt)	Cu (%)	As (%)	Zona	Orígen Lote	Tipo Mineral	Cancha
20-10700	2.933	10.5	0.2	0.76		Artesanos	MO01	Cancha óxidos
20-10967	2.613	215.07	0.01	0.01		Artesanos	MO01	Cancha óxidos
20-11079	2.75	69.98	0.08	0.04		Artesanos	MO01	Cancha E
20-11410	63.90	3.35	0.65	0.04		Artesanos	MS01	Cancha Sulfuros
20-11848	36.712	44.01	1.07	0.02		Artesanos	MS01	Cancha Sulfuros
20-11884	109.803	29.2	0.16	0.09		Artesanos	MO01	Cancha óxidos
20-12029	51.648	3.63	0.37	0.04		Artesanos	MS01	Cancha Sulfuros

Issues:

- Only a few parameters

- Many small production sites

© Barbara.Beck@unil.ch, Stefan Ansermet
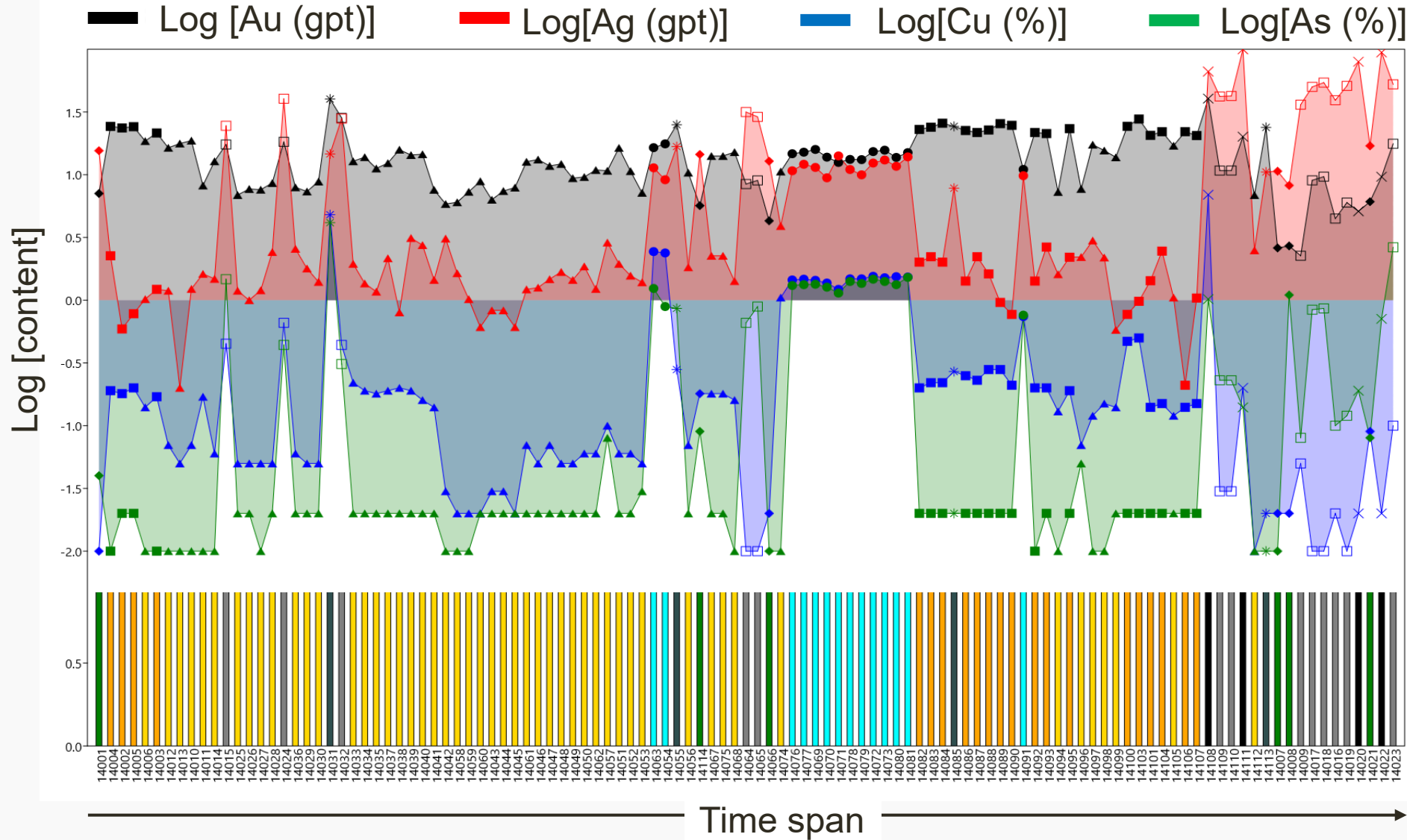
Graphic report
- 1 mine

Observations
- Variations in the ore mined due to the geological context
- Time evolution
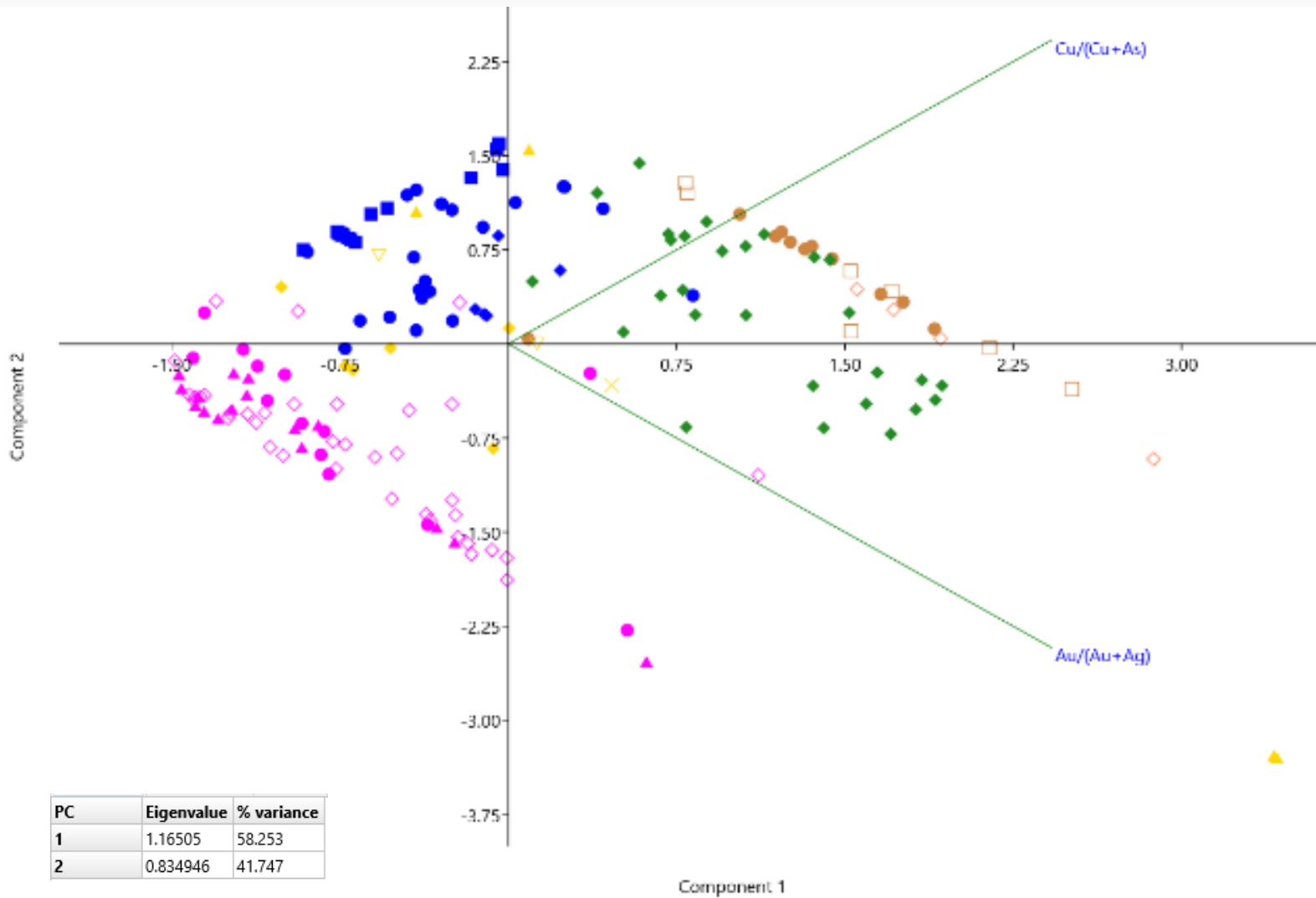
Principal component analysis (PCA)
- ~ 40 small suppliers
- 6 different regions (blue, green, brown, yellow, pink)

Observations
- Regional differences
- It is not possible to distinguish mine by mine
- Results could be easily improved by adding one or two elements to the already existing analytical protocol

PC	Eigenvalue	% variance
1	1.16505	58.253
2	0.834946	41.747

Geoforensic passport:
- GP visa «Refinery»
- GP visa «Refinery ASM»
- GP visa «Collector LSM»
- GP visa «Collector ASM»
- 1. GP visa «ASM – LSM»
- GP visa «single mine ASM»
- 2. GP visa «single mine LSM»
- 3. GP visa «consumer»
- ….

D. Ruppen, BGR, Kampene 2015

Implementation of the GP in an artisanal context: the Kokumbo mine, Ivory Coast
- **Set up a formalized supply chain for a small mining district.**
- **Link between artisanal and industrial mining.**

Context:
Interface between industrial mining and artisanal production

Main goals:
Legitimising and protecting ASM production
Ensuring and shortening access to a legal supply chain
Selling gold at a better market price

Technical main issues:
Distinguish between gold produced in artisanal operations and gold produced in industrial mines

Collaboration:
University of Abidjan, Ivory Coast

Certifing the origin of the Gold produced in an LSM context

Context:
Primary poduction sites LSM

Main goals:
Guaranteeing the origin of gold in the first production step of the whole supply chain

Technical main issues:
Quality of analysis
Homogeneity of production (metal, slag, etc)

Collaborations:
Gold mines

From the mine to the end consumer

Context:
Meet the end consumer's need for due diligence

Main goals:
Establishing a responsible supply chain that guarantees the origin of the gold to the end consumer

Collaborations:
Luxury industry in Switzerland

The Geoforensic Passport (GP) is:

- a technical tool that is undoubtedly beyond an administrative procedure.

- by design, immune from declaratory fraud.

- a very safe, scientifically proven and reliable anomaly detection tool.

Implementation criteria
- Supply chain

  ➤ The GP can be implemented in various contexts, already at the very beginning of the supply chain, ideally at the bottlenecks in the supply chain

- Analysis

  ➤ The quality of the results depends on the quality of the analyses
  ➤ It is important to be able to rely on a historical database, from a few months before the implementation of the GP

What to do with traceability tools?

➢ What traceability tools exist?

➢ What are the challenges of gold traceability in producing countries?

➢ What does gold traceability bring to the various stakeholders in Switzerland?

➢ What to do with traceability tools? Should they be institutionalized?

Conferences and workshop on gold traceability

University of Lausanne, Switzerland, May 2/3, 2023

gold.traceability@unil.ch

Thank you for your attention!

Questions?

Chinese sales staff walk along an aisle paved with gold bars, estimated to be worth over 100 million yuan ($16 million), at a gold exchange house in Kunming, China, Dec. 11, 2012.