



Geoforensic Passport

A scientific tool to confirm
the origin of mined gold

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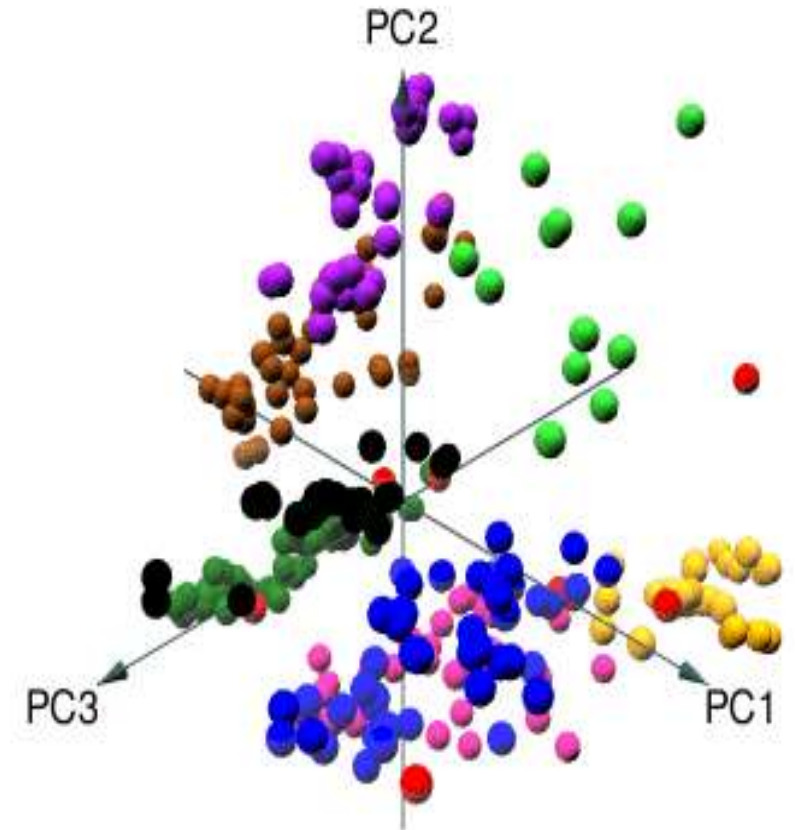
1. What is the Geoforensic Passport ?

Tool

Based on chemical composition of doré bars

Link from ore body/mine to refinery/checkpoint

To reliably confirm the supplier's declared origin for every **doré** or **ores**

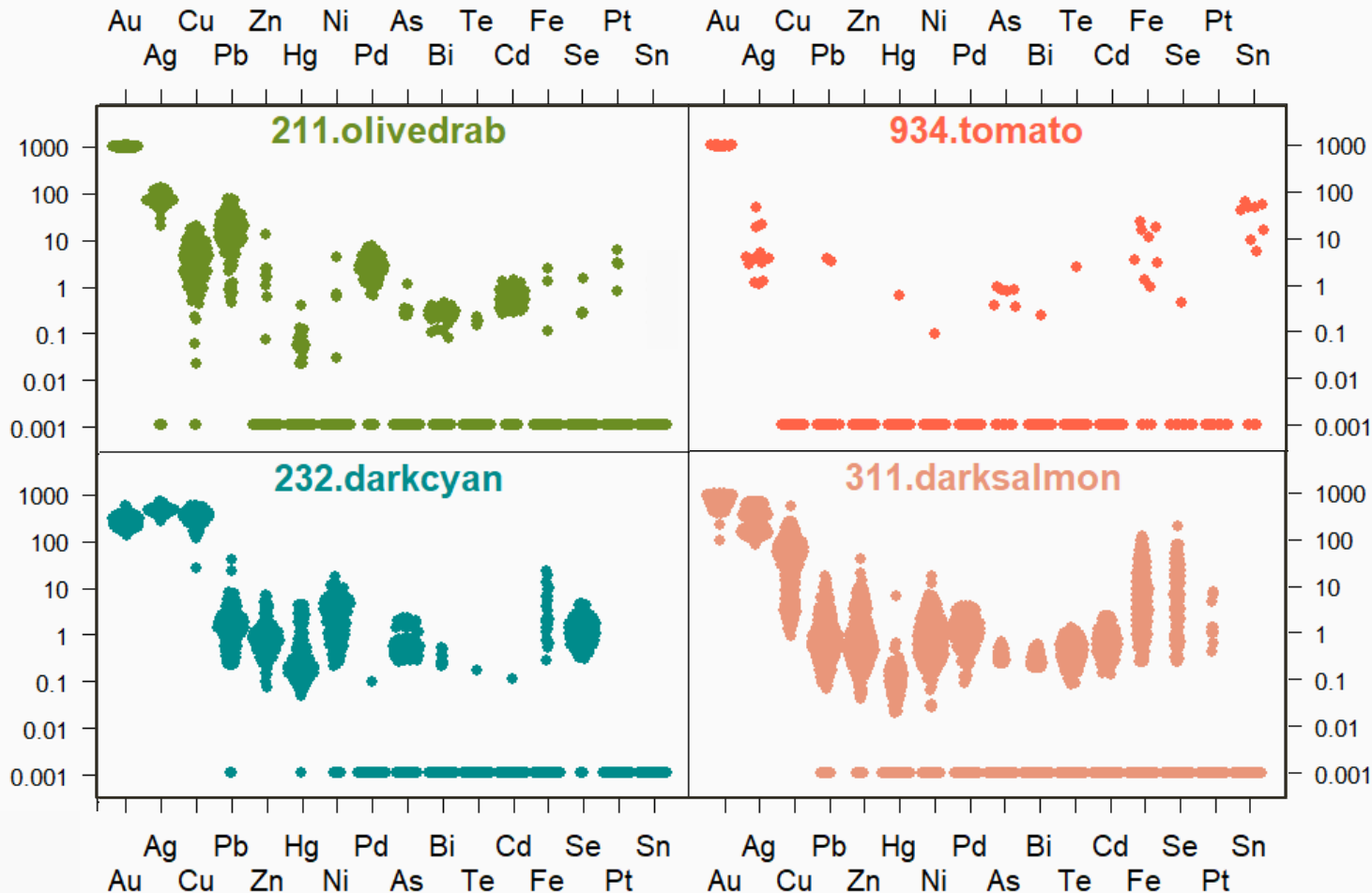


Statistical model of a doré-supplier. Each dot represents a doré.

2. What is the Geoforensic Passport based on?

What is the GP based on?

Secondary ore deposits: Amazonian Bassin



Primary ore deposits:
Andean Mountains

Primary ore deposits:
Red sea

Chemical composition depends on:

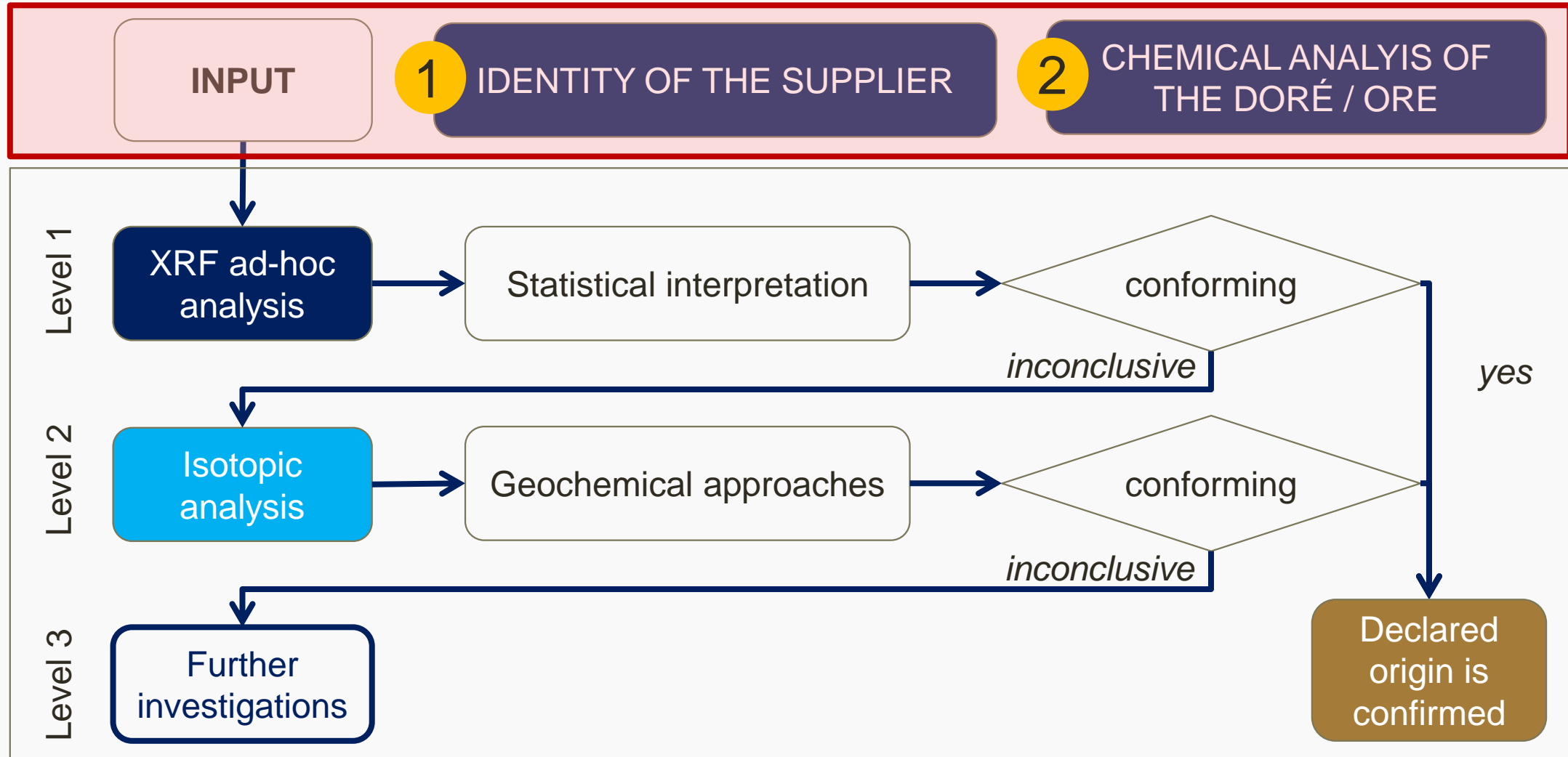
- (Pre)- Refining process
- Geological context

Beeswarms

- 4 suppliers (=colors)
- Doré samples (=dots)
- 16 elements of 20
- Logarithmic scale

3. How does the Geoforensic Passport work ?

How does the Geoforensic Passport work ?



| No sample | Supplier /Origin | Chemical composition | Real origin | Declaration of origin |
|-----------|------------------|----------------------|-------------|-----------------------|
| T1 | Black | YES | Black | TRUE |
| T2 | Black | YES | Black | TRUE |
| F3 | Black | YES | Darkgreen | FALSE |
| F4 | Black | YES | Darkkhaki | FALSE |

INPUT

| No sample | Supplier /Origin | Chemical composition | Real origin |
|-----------|------------------|----------------------|-------------------|
| T1 | Black | YES | Black |
| T2 | Black | YES | Black |
| F3 | Black | YES | Darkgreen |
| F4 | Black | YES | Darkkhaki |
| R5 | Black | YES | 100% La Rinconada |



INPUT

| No sample | Supplier /Origin | Chemical composition | Real origin | Declaration of origin |
|-----------|------------------|----------------------|-----------------------------|-----------------------|
| T1 | Black | YES | Black | TRUE |
| T2 | Black | YES | Black | TRUE |
| F3 | Black | YES | Darkgreen | FALSE |
| F4 | Black | YES | Darkkhaki | FALSE |
| R5 | Black | YES | 100% La Rinconada | FALSE |
| R6 | Black | YES | 90% La Rinconada, 10% Black | FALSE |
| R7 | Black | YES | 30% La Rinconada, 70% Black | FALSE |
| R8 | Black | YES | 20% La Rinconada, 80% Black | FALSE |
| R9 | Black | YES | 10% La Rinconada, 90% Black | FALSE |

INPUT

Photos: S. Ansermet



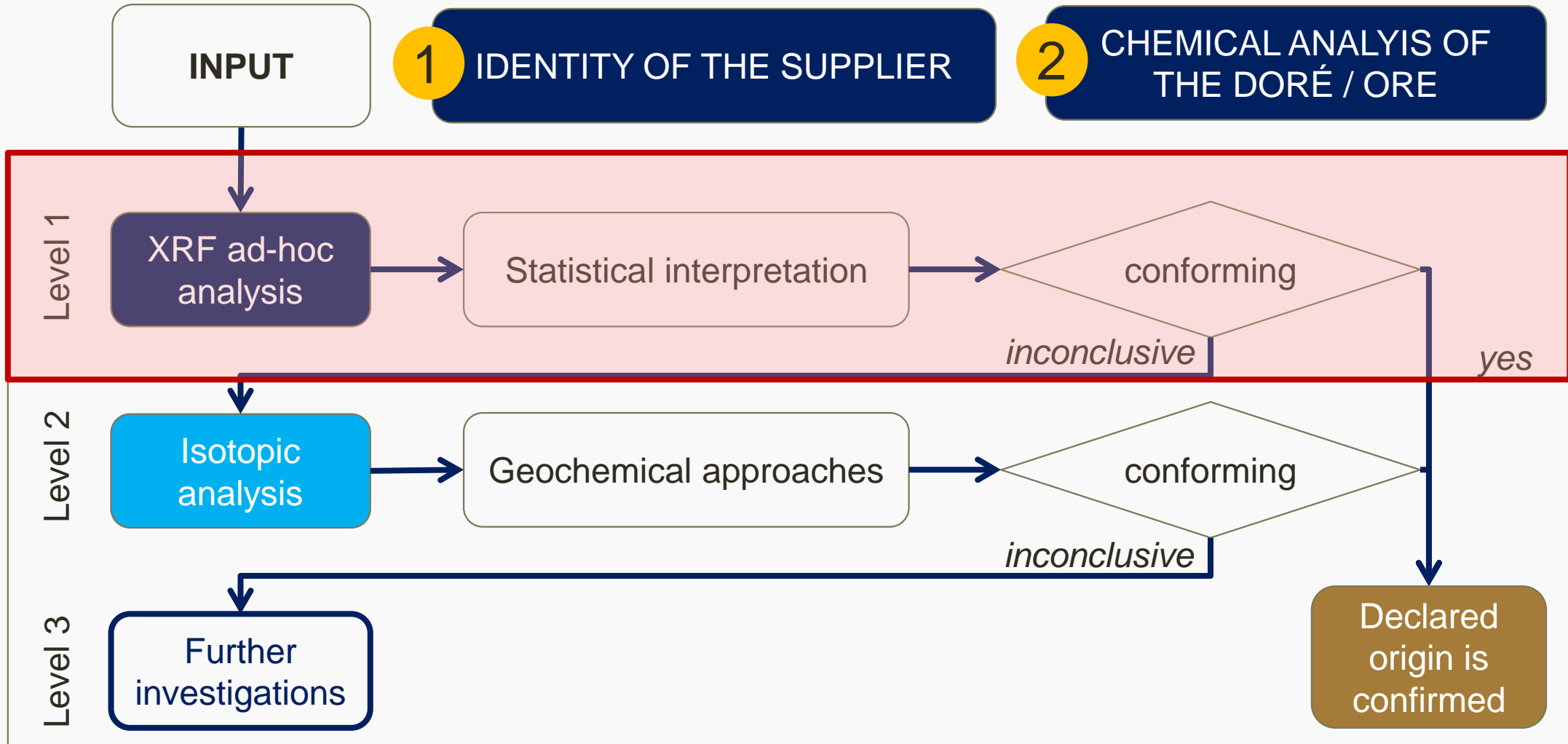
| | | | |
|-----|-------|-----|------------------------------|
| M10 | Black | YES | 100% Madre de Dios |
| M11 | Black | YES | 20% Madre de Dios, 80% Black |
| M12 | Black | YES | 10% Madre de Dios, 90% Black |



INPUT

| No sample | Supplier /Origin | Chemical composition | Real origin | Declaration of origin |
|-----------|------------------|----------------------|------------------------------|-----------------------|
| T1 | Black | YES | Black | TRUE |
| T2 | Black | YES | Black | TRUE |
| F3 | Black | YES | Darkgreen | FALSE |
| F4 | Black | YES | Darkkhaki | FALSE |
| R5 | Black | YES | 100% La Rinconada | FALSE |
| R6 | Black | YES | 05% La Rinconada, 95% Black | FALSE |
| R7 | Black | YES | 10% La Rinconada, 90% Black | FALSE |
| R8 | Black | YES | 20% La Rinconada, 80% Black | FALSE |
| R9 | Black | YES | 30% La Rinconada, 70% Black | FALSE |
| M10 | Black | YES | 100% Madre de Dios | FALSE |
| M11 | Black | YES | 10% Madre de Dios, 90% Black | FALSE |
| M12 | Black | YES | 20% Madre de Dios, 80% Black | FALSE |

PROCESSING LEVEL 1



OUTPUT

| No sample | Real origin | Declaration of origin |
|-----------|--------------------|-----------------------|
| T1 | Black | TRUE |
| T2 | Black | TRUE |
| F3 | Darkgreen | FALSE |
| F4 | Darkkhaki | FALSE |
| R5 | 100% La Rinconada | FALSE |
| R6 | 05% La Rinconada | FALSE |
| R7 | 10% La Rinconada | FALSE |
| R8 | 20% La Rinconada | FALSE |
| R9 | 30% La Rinconada | FALSE |
| M10 | 100% Madre de Dios | FALSE |
| M11 | 10% Madre de Dios | FALSE |
| M12 | 20% Madre de Dios | FALSE |

| | TEST1 | TEST2 | TEST3 |
|-----|-------|-------|-------|
| T1 | <NA> | <NA> | TRUE |
| T2 | <NA> | <NA> | TRUE |
| F3 | F3 | F3 | FALSE |
| F4 | F4 | F4 | FALSE |
| R3 | R3 | R3 | FALSE |
| R6 | <NA> | R6 | FALSE |
| R7 | <NA> | R7 | FALSE |
| R8 | <NA> | R8 | FALSE |
| R9 | <NA> | R9 | FALSE |
| D3 | D3 | D3 | FALSE |
| D11 | <NA> | D11 | FALSE |
| D12 | <NA> | D12 | FALSE |



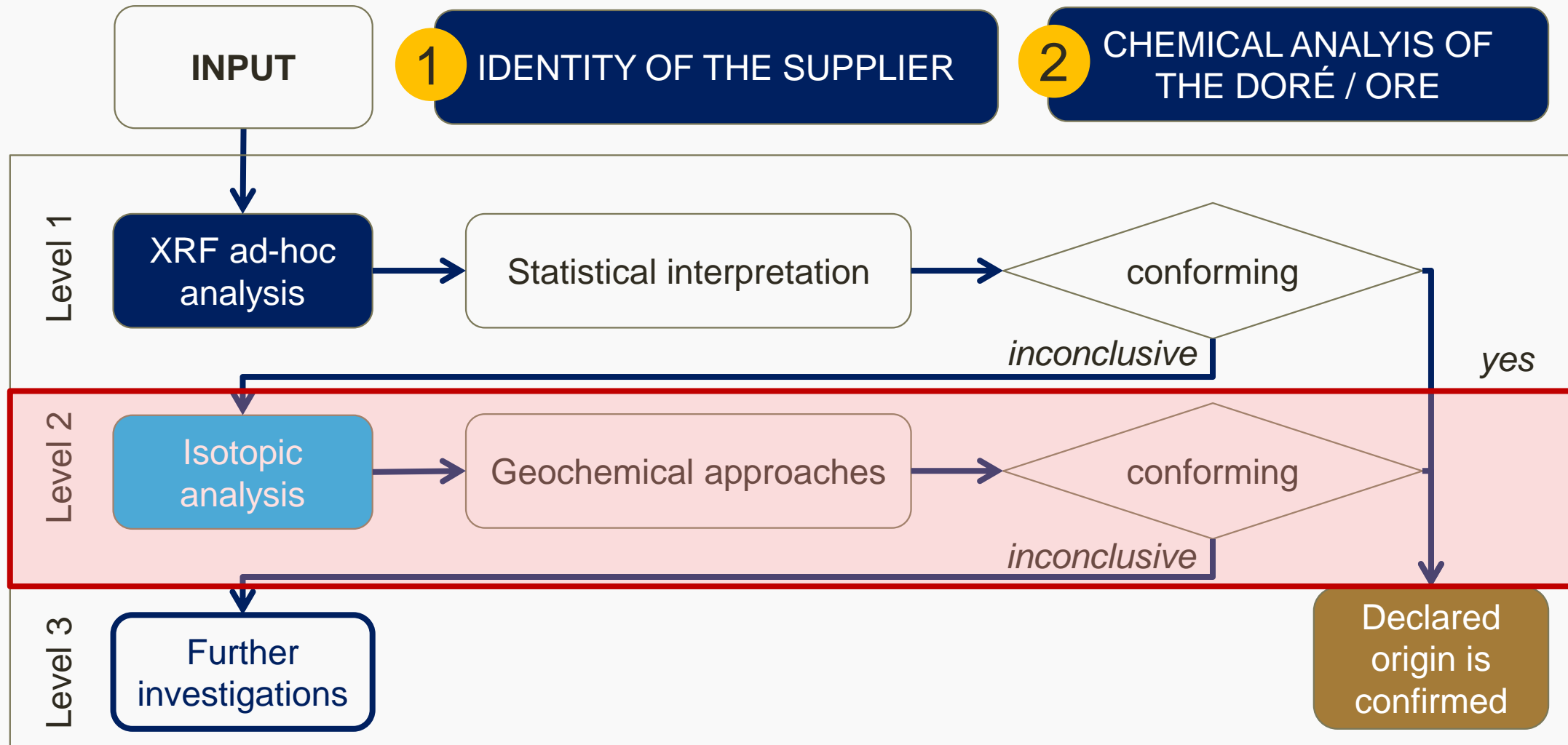
are part of the reference supplier (black)



the signature does not match the reference supplier (black)

4. What to do with a non-compliant sample ?

FURTHER INVESTIGATIONS



5. What are the possible applications?

Geoforensic passport:

- GP visa «Refinery»
- GP visa «Refinery ASM»
- GP visa «Collector LSM»
- GP visa «Collector ASM»
- GP visa «ASM – LSM»
- GP visa «single mine ASM»
- GP visa «single mine LSM»
- GP visa «consumer»
-

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D. Ruppen, BGR, Kampene 2015

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-



6. Conclusion

Technical feasibility

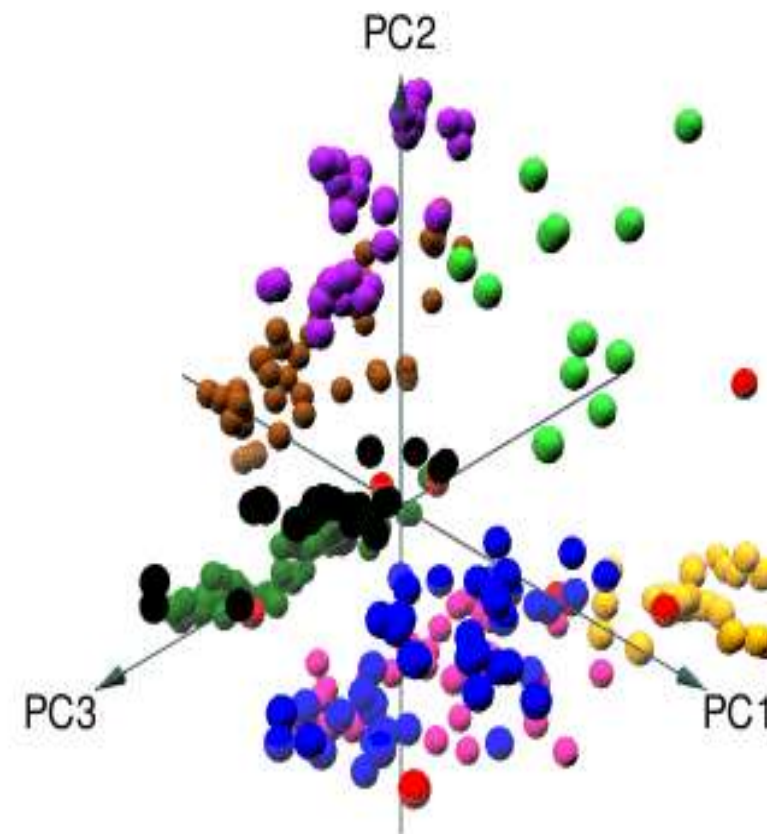
- **Confirmation of origin** is possible using a scientific, multistep method
 - Even small percentage mixtures (< 10%) can be detected
 - **Link from vein / mine to refinery**

Our solution

- Routine implementation in an already existing processing/refining process
- Use in an LSM and ASM context

Requirements of a checkpoint

- Quick method using **existing analytical equipment**
- Integration in existing flows: systematic analysis & **low cost**



Statistical model of a doré-supplier.
Each dot represents a doré.



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.