Mining waste characterization in the perspective of the European mining waste directive

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Characterisation of mining waste (and more generally extractive waste): purpose

Place in the European mining policy

A key activity in the environmental management of extractive industries

Desired by the European Union in the perspective of improving their sustainability

IPPC applies to mining, but the size (more than 4700Mt of mining waste and 1200Mt of tailings in 2000) and types of waste needed a specific management policy

Prevention of mining disasters, following Spain (1999), Romania (2000) and Hungary (2010)

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Characterisation of mining waste: scope

- **Waste characterisation applies to:**
  - all mines (open cast or underground) and quarries,
  - all mining activities (extraction, beneficiation, restoration),
  - any status (active, closed or abandoned),
  - all commodities (metals, coal or industrial minerals)

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Characterisation of mining waste: scope

The main waste categories are extraction waste and processing waste, with markedly different properties, and subsequently of waste forms

Extraction waste further subdivided in overburden, barren host rocks, and low grade mineralised rocks

extraction waste	processing waste
Coarse material abundant, large heterogeneity	Most fine-grained, sandy or silty, homogeneous
Ore elements in variable amounts	Valorised elements depleted Unused elements concentrated
Mechanically dumped	Slurry decantation

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Waste categories in the extractive industry

The Mining Waste Directive (2006/21/EC, or MWD) defines

- **inert waste (IW) ,**
- **hazardous waste (HW)**
- **non-inert, non-hazardous waste (NINHW)**

HW: Definition closely derived from the definition of hazardous waste in the Waste Directive (91/689/EEC)

IW: Specific definition (MWD, appendix II, and Decision 2009/359/EC)

NINHW: No definition: what is neither HW nor IW
NINHW needs appropriate management too

Strategies in order to assess the inert or hazardous character of waste, in relation with the Directive and following a General Guidance still under elaboration.

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From waste characterisation to waste management

One major objective of waste characterisation is to contribute to a sustainable and safe management of mining waste facilities (MWFs).

Specific dispositions are applicable to:

- extraction waste (waste rock) dumps, mostly in rock heap form, and
- processing waste dumps, mostly as layered fine-grained (tailings) dams,

depending on waste characteristics ("Category A mining waste").

"Kirchheller Heide" Area (Bottrop, Germany, Deutsche Steinkohle AG)

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From waste characterisation to waste management

Detailed and site-specific characterisation programs may be required to meet the requirements of waste facilities approval.

(design of Category A or B mining waste facilities)

Adequate and comprehensive characterisation programs may be expensive and time-consuming

They may however allow significant savings in the MWF construction and operation

Finding out later that a MWF was inadequately built is even more expensive

Waste characterisation is an important part of efficient mine site management

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From waste characterisation to waste management: Criteria for determining the classification of waste facilities

A waste facility shall be classified under category A if:

- **a failure or incorrect operation, e.g. the collapse of a heap or the bursting of a dam, could give rise to a major accident, on the basis of a risk assessment taking into account factors such as the present or future size, the location and the environmental impact of the waste facility; or**
- **it contains waste classified as hazardous under Directive 91/689/EEC above a certain threshold; or**
- **it contains substances or preparations classified as dangerous under Directives 67/548/EEC or 1999/45/EC above a certain threshold.**

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Technical Requirements for Waste Characterisation

Item	Requirement	Details
1	**Background information**	Should provide basic information on the background and objectives of the extractive operation, for example: –**prospecting, extraction and/or processing activities;** – **type and description of method of extraction and process applied** – **nature of the intended product.**

Technical Requirements for Waste Characterisation

Item	Requirement	Details
2	Geological background of deposit to be exploited	Information on the units to be exposed and which will be the source of the waste. Details required include: • nature of surrounding rocks, their chemistry and mineralogy, including hydrothermal alteration of mineralised rocks and barren rocks; • nature of deposit, including mineralised rocks or rock-bearing mineralisation; • mineralisation typology, chemistry and mineralogy, including physical properties such as density, porosity, particle size distribution, water content, covering worked minerals, gangue minerals, hydrothermal newly-formed minerals; • weathering and supergene alteration from the chemical and mineralogical point of view.

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Technical Requirements for Waste Characterisation

Item	Requirement	Details
3	Nature of the waste and its intended handling	Details on all wastes to be generated from prospecting, extraction and processing, including: • origin of the waste in the extraction site and the process generating that waste such as prospecting, extraction, milling, concentration; • total quantity of extractive waste to be produced; • description of the waste transport system; • description of the chemical substances to be used during treatment; • classification of the waste according to the LOW, including identification of hazardous properties; and • type of intended waste facility, final form of exposure of the waste and method of deposition of the waste into the facility.

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Technical Requirements for Waste Characterisation

Item	Requirement	Details
4	Geotechnical behaviour of the waste	**Laboratory characterization and testing:** compressibility, shear strength, angle of friction, grain size distribution, density (bulk density and specific weight), plasticity, fracturing (if appropriate), liquefaction potential, permeability and erosion potential. Accurate measurements but sample size is generally small. Sampling strategy crucial to ensure representative samples, up scaling of results needs care. **In-situ tests** less accurate, but more “integrating”. Valid for a larger volume. Only applicable to already existing dumps and tailings storage facilities, their relevance for initial testing in the planning stage is limited.

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Technical Requirements for Waste Characterisation

Item	Requirement	Details
5	Geochemical characteristics and behaviour of the waste	Details on the chemical and mineralogical characteristics of the waste, and of any additives or residuals remaining in the waste, in particular: • evaluation of metals, oxyanion and salt leachability over time by pH dependence leaching test, and/or percolation test and/or time-dependent release and/or other suitable testing; • for sulphide-containing waste, static or kinetic tests should be carried out in order to determine acid-rock drainage and metal leaching over time.

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Characterisation of mining waste: nomenclature

Classification of waste in accordance with the European Waste Catalogue

Waste from extractive industries belongs to class 01 : *"Wastes resulting from exploration, mining, quarrying, and physical and chemical treatment of minerals"*

The six-digit codes in the LOW having an asterisk next to them are hazardous wastes. Wastes without an asterisk are not hazardous wastes.

Hazardous wastes coloured in red: "Absolute" hazardous entries

Hazardous wastes coloured in blue: "Mirror" hazardous entries

The absolute hazardous entries are automatically considered hazardous and their description does not have a reference to "dangerous substances".

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Characterisation of mining waste: nomenclature

"*Absolute Entries*"	- Hazardous waste regardless of any threshold concentrations:	A
"*Mirror Entries*"	- Hazardous waste only if dangerous substances are present above threshold concentrations:	M

01	Wastes Resulting from Exploration, Mining, Quarrying, and Physical and Chemical Treatment of Minerals	
01 01	**wastes from mineral excavation**	
01 01 01	wastes from mineral metalliferous excavation	
01 01 02	wastes from mineral non-metalliferous excavation	
01 03	**wastes from physical and chemical processing of metalliferous minerals**	
01 03 04*	acid-generating tailings from processing of sulphide ore	A
01 03 05*	other tailings containing dangerous substances	M
01 03 06	tailings other than those mentioned in 01 03 04 and 01 03 05	
01 03 07*	other wastes containing dangerous substances from physical and chemical processing of metalliferous minerals	M
01 03 08	dusty and powdery wastes other than those mentioned in 01 03 07	
01 03 09	red mud from alumina production other than the wastes mentioned in 01 03 07	
01 03 99	wastes not otherwise specified	
01 04	**wastes from physical and chemical processing of non-metalliferous minerals**	
01 04 07*	wastes containing dangerous substances from physical and chemical processing of non-metalliferous minerals	M
01 04 08	waste gravel and crushed rocks other than those mentioned in 01 04 07	
01 04 09	waste sand and clays	
01 04 10	dusty and powdery wastes other than those mentioned in 01 04 07	
01 04 11	wastes from potash and rock salt processing other than those mentioned in 01 04 07	
01 04 12	tailings and other wastes from washing and cleaning of minerals other than those mentioned in 01 04 07 and 01 04 11	
01 04 13	wastes from stone cutting and sawing other than those mentioned in 01 04 07	
01 04 99	wastes not otherwise specified	
01 05	**drilling muds and other drilling wastes**	
01 05 04	freshwater drilling muds and wastes	
01 05 05*	oil-containing drilling muds and wastes	M
01 05 06*	drilling muds and other drilling wastes containing dangerous substances	M
01 05 07	barite-containing drilling muds and wastes other than those mentioned in 01 05 05 and 01 05 06	
01 05 08	chloride-containing drilling muds and wastes other than those mentioned in 01 05 05 and 01 05 06	
01 05 99	wastes not otherwise specified	

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Characterisation of mining waste: standards

Objectives of CEN/TC 292 WG8:

Characterisation of waste from the extractive industry

Accompany Europe in waste management through the standardisation of nomenclature, standardized tests required for waste characterisation

Develop and provide standards describing procedures to determine the characteristics of waste, including waste behaviour.

Assist Europe in its regulatory effort on waste and secondary raw materials

=> This includes sampling, pre-treatment, leaching properties, determination of total content of species, determination of sum parameters, assessment of ecotoxicity, proposition of test reports and subsequent terminology.

Tasks of CEN/TC 292 WG8: Work items

Characterisation of waste from the extractive industry

Work item 1 covering the production of an **overall guidance document** led by Ingar Walder with contributions from others including Hans van der Sloot, Ole Hjelmar, David Bendz and Ferenc Madai.
Work item 2 covering the production on **sampling examples** led by Margareta Wahlström with contributions from others including Ingar Walder, Irena Twardowska and Jane Turrell.
Work item 3 covering the robustness and validation study on the **static test** led by Margareta Wahlström with contributions from others including Hans van der Sloot, Ingar Walder and Irena Twardowska.
Work item 4 on the production of a document on **kinetic testing** led by Ingar Walder with contributions from others including Hans van der Sloot, David Bendz and Ferenc Madai.
Work item 5 on the production of a document on sampling and analysis of **WAD Cyanides** led by Klaus Liphard with contributions from others including Tommi Kaartinen.

Characterisation of mining waste: standards

	Project reference	Title	Current status	DAV
00292053	prEN 15875	Characterization of waste - Static test for determination of acid potential of sulfidic waste	Under Approval	2012-04
00292065		Characterization of waste - Acid generation behaviour - Kinetic testing of sulfidic waste from extractive industries	Under Drafting	2012-05
00292066		Characterization of waste - Overall guidance document for characterization of waste from extractive industries	Under Drafting	2012-05
00292067	FprCEN/TS 16229	Characterization of waste - Sampling and Analysis of weak acid dissociable cyanide discharged into tailings ponds	Under Approval	2011-07
00292071		Characterization of waste - Sampling of waste from extractive industries	Under Drafting	2012-05

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Characterisation methods for mining waste in Europe

Characterisation methods include:

- those explicitly required by the MWD for assessing the hazardous or inert character of each waste
- those aimed at MWFs management
- those aimed at a good understanding of the geological environment of the MWFs, and therefore playing a significant role in the effectiveness of MWF design, and risk analyses.

Can they really be applicable elsewhere ?

- The applicability of characterisation methods outside Europe is also desirable, as it contributes to the sustainability of the mineral supply chain.

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Characterisation methods for mining waste

- Specific to mine waste (WG8) (under development)
- General methods applied to mine waste

- Sampling
  - standardised methods (under development)
  - industry good practice (similar to ore evaluation)

- Laboratory methods
  - standardised methods (ISO/CEN, but also US-EPA, ASTM, etc)
  - industry good practice
  - chemical, mineralogical, geotechnical data
  - data quality objectives

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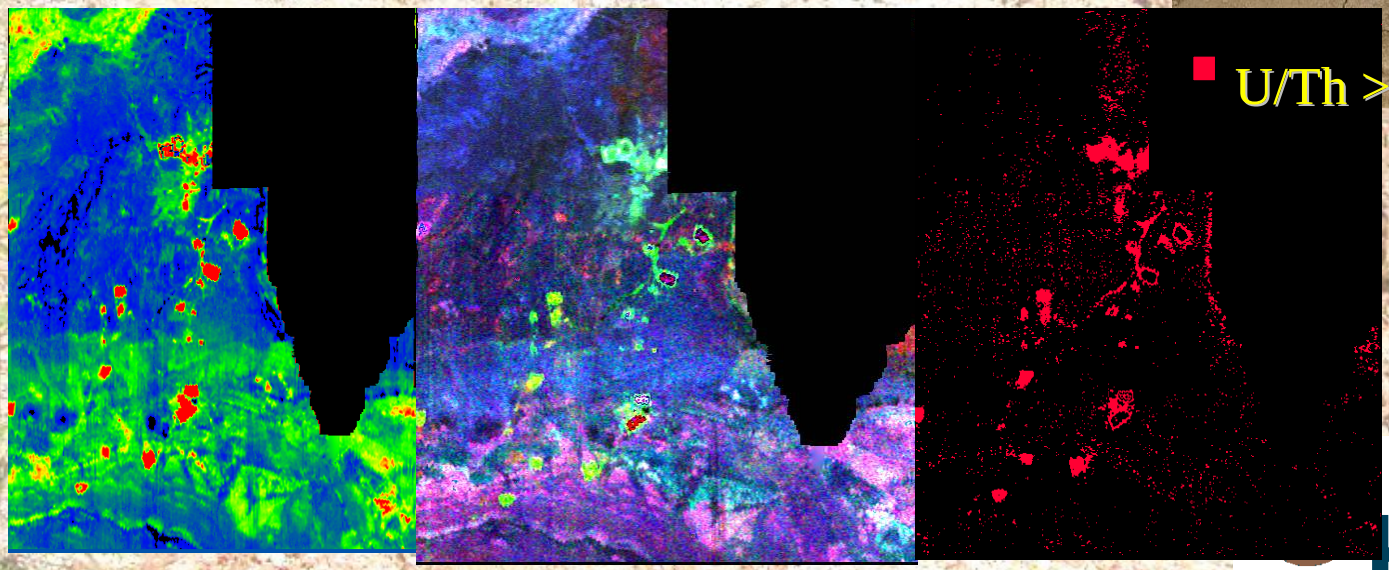
Characterisation methods for mining waste

- Field methods
  - Site screening, mapping large areas
  - Lab sample selection optimisation
- Site methods
  - geological investigations
  - geophysics
  - remote sensing, airborne measurements



Total count

K, U, Th

Pollution map

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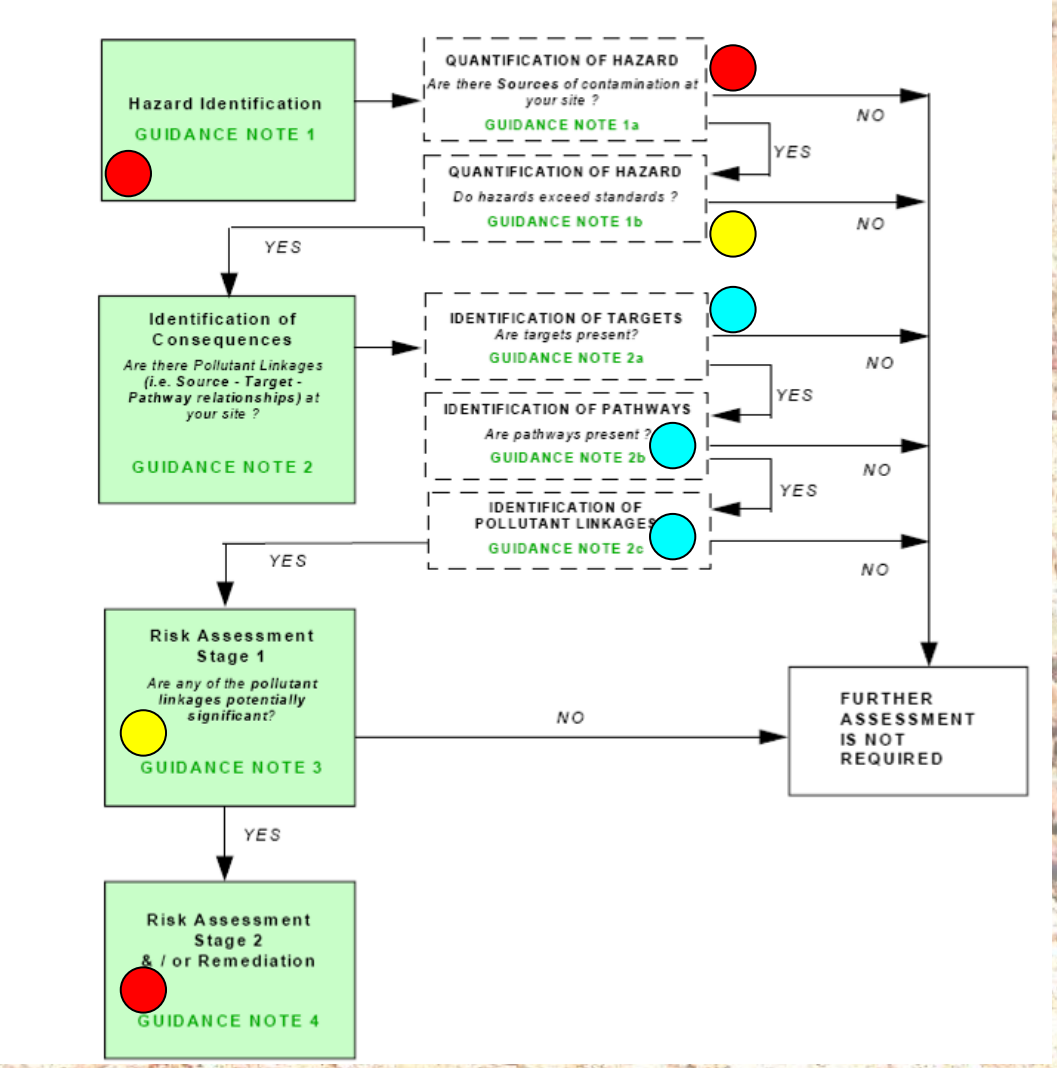
Characterisation and risk assessment



- Critical data from waste
- Waste data included in other investigations
- Waste data orientate other investigations

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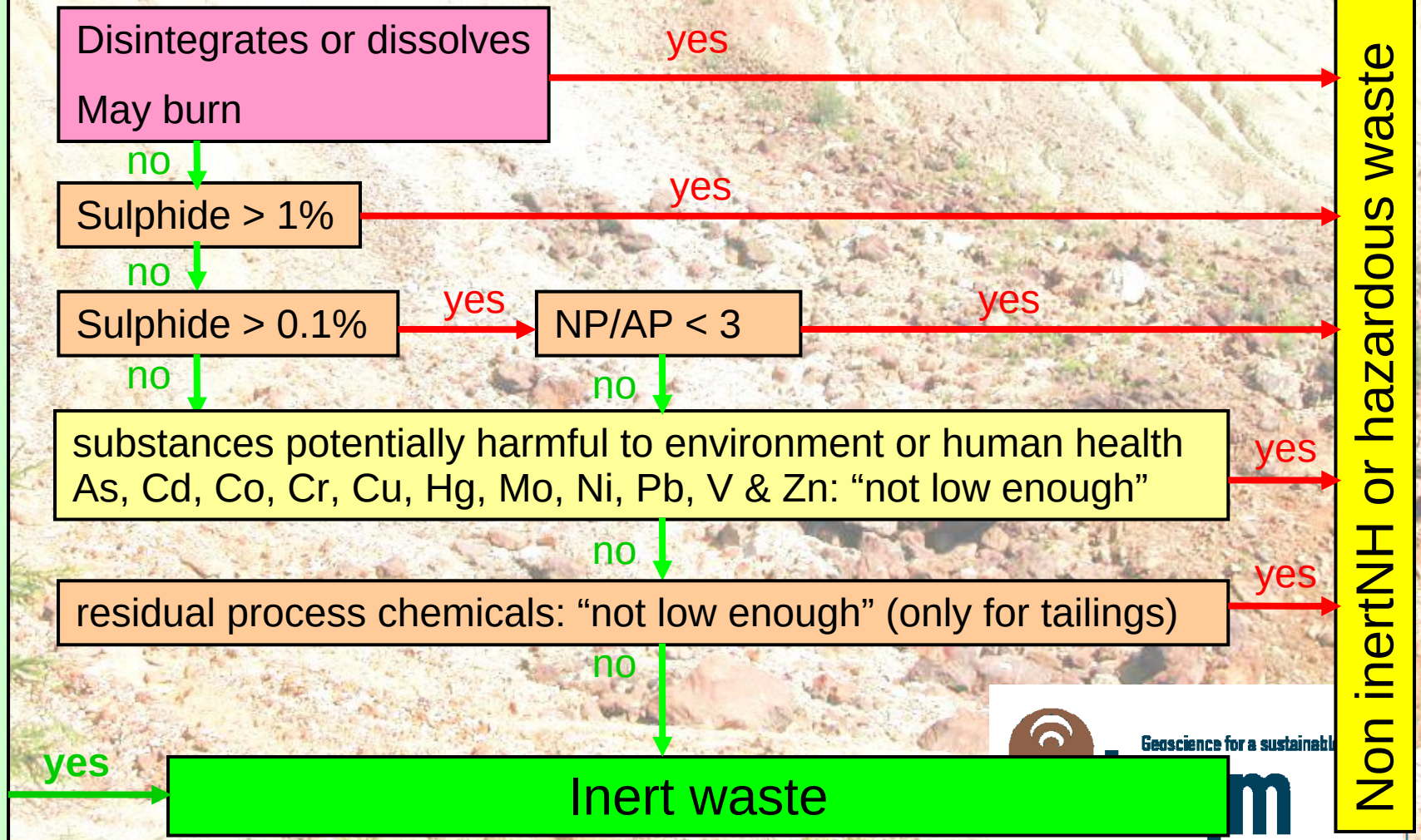
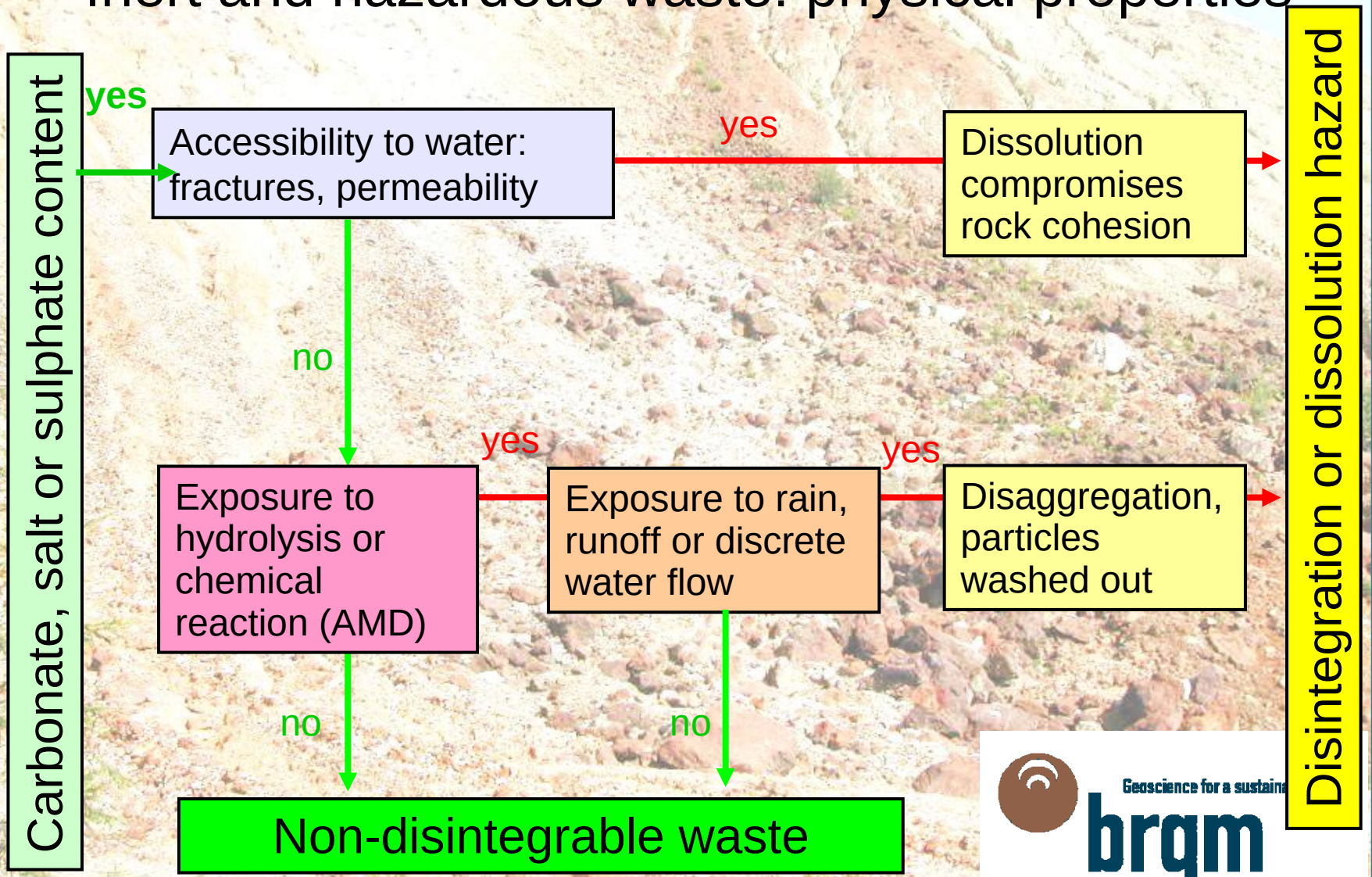
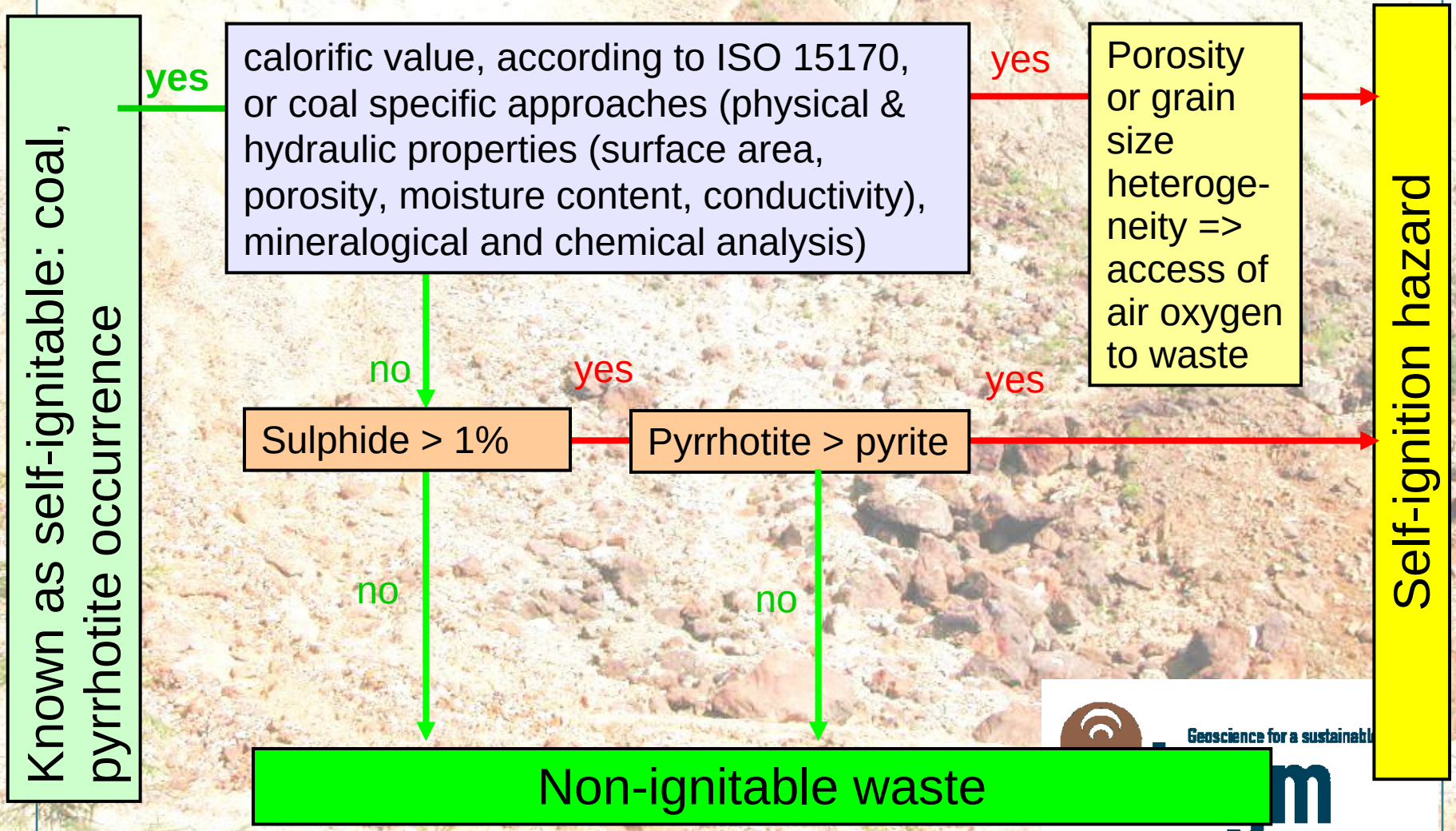
Inert waste and 2009/359/EC



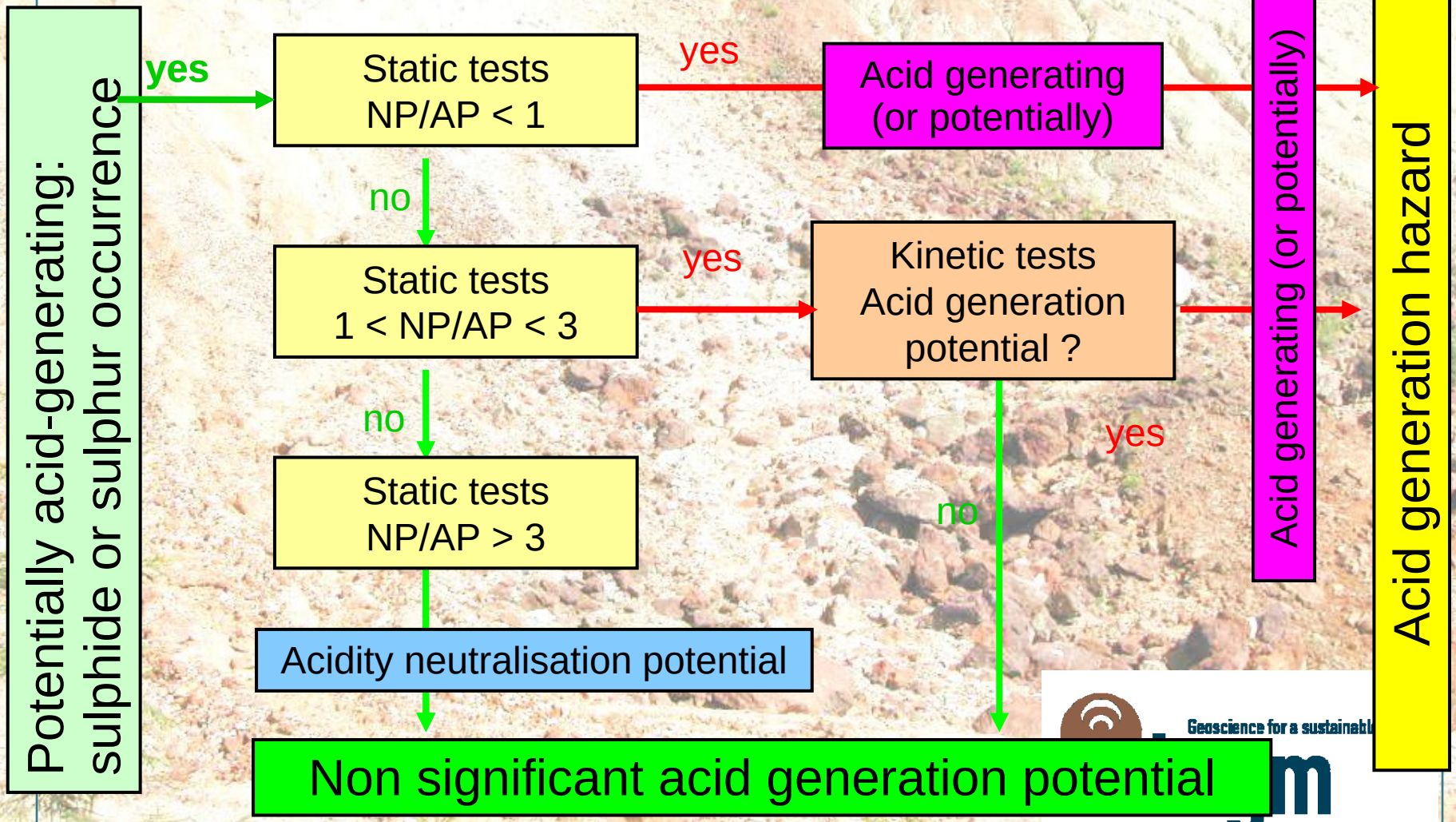
Inert and hazardous waste: physical properties

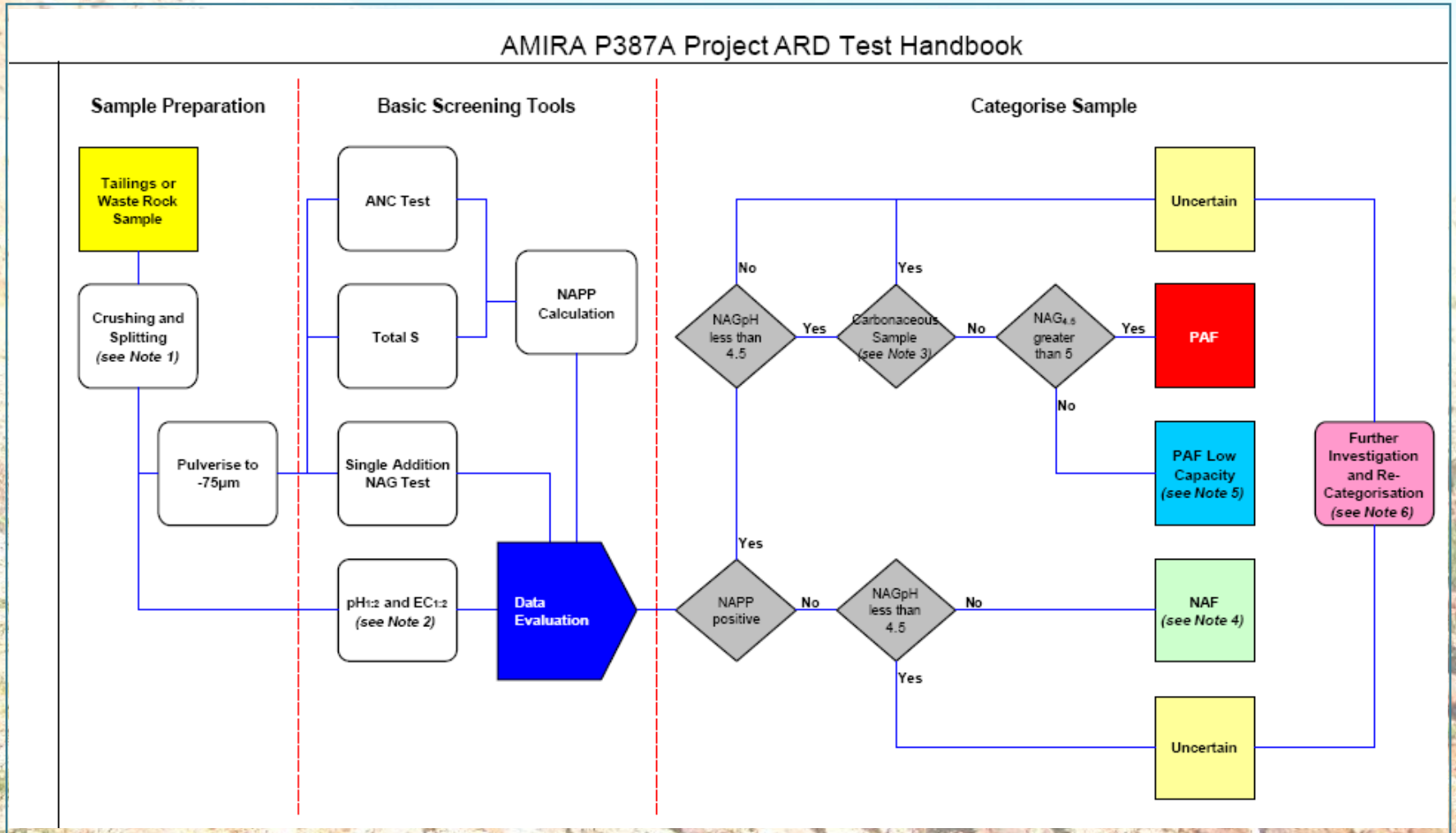


Inert and hazardous waste: self-ignition properties



Inert and hazardous waste: acid generation properties





Flow Chart showing ARD screening tests, decision nodes and ARD rock type categories

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Inert waste and 2009/359/EC

Waste with uncertain acid-generating potential

Significant contents in substances potentially harmful to environment or human health As, Cd, Co, Cr, Cu, Hg, Mo, Ni, Pb, V & Zn (plus specific ones) – total digestion or analysis

ref

Reference values for « significant contents » (solid waste or leachate) are nationally defined, or result from geochemical background, or from risk analysis

yes

ref

Partial digestion and extraction sequences: availability of these substances

ref

no

yes

Leaching tests: released substances

yes

Non inert NonHaz or hazardous waste

no

no

Inert waste

Hazardous waste and 1991/689/EC

Applicable to usual mine waste
(H4) irritant substances
(H5) harmful substances
(H6) toxic substances
(H7) carcinogenic substances
(H8) corrosive substances
(H10) teratogenic substances
(H11) mutagenic substances
(H13) substances that may release potentially dangerous leachates
(H14) ecotoxic substances

Applicable to specific mine waste
(H3) highly flammable substances:
COAL WASTE
(H12) may release toxic gases:
CYANIDE PROCESSING WASTE

Non applicable to mining waste
(H1) explosive substances
(H2) oxidising substances
(H9) infectious substances

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Hazardous waste and 1999/45/EC

Types of hazardous waste according to activity which generated them

Some of the following substances may be found in mining waste, due to present or past extraction machinery or processing reagents (refs in Annex I):

5. residue from substances employed as solvents
6. halogenated organic substances not employed as solvents excluding inert polymerized materials
7. tempering salts containing cyanides
8. mineral oils and oily substances (e.g. cutting sludges, etc.)
9. oil/water, hydrocarbon/water mixtures, emulsions
10. substances containing PCBs and/or PCTs (e.g. dielectrics etc.)
11. tarry materials arising from pyrolytic treatment (e.g. still bottoms, etc.)
15. pyrotechnics and other explosive materials

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Hazardous waste and 1999/45/EC

Types of hazardous waste according to activity which generated them
The following substances may be found in mining waste, according to the commodity mined (refs in Annex II), and may render it hazardous when they have the properties described in Annex III:

C1	**Be**	C7	**Zn**	C13	**Sb**
C2	**V**	C8	**As**	C14	**Te**
C3	**Cr(VI)**	C9	**Se**	C15	**Ba**
C4	**Co**	C10	**Ag**	C16	**Hg**
C5	**Ni**	C11	**Cd**	C17	**Tl**
C6	**Cu**	C12	**Sn**	C18	**Pb**

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Hazardous waste and 1999/45/EC

Types of hazardous waste according to activity which generated them (ctd)

C19: **sulphides**	C36 creosotes (if mine wood was processed on site);
C20: **Fluor (not CaF)**	C37 isocyanates; thiocyanates
C21: **cyanide**	C39 phenols; phenol compounds
C23: Acidic solutions	C40 halogenated solvents (spills)
C24: basic solutions or bases in solid form	C41 organic solvents, excluding halogenated solvents (spills)
C25 **asbestos** (dust and fibres);	C43 aromatic compounds; polycyclic and heterocyclic
C32 PCBs and/or PCTs (from spills);	C47 substances of an explosive character
C48 sulphur organic compounds	

Waste management optimisation

Careful separation of hazardous and other waste according to characterisation results allows to reduce the final volume of HW

Well planned waste repositories for potentially acid generating waste, based on accurate ABA and kinetic tests reduces the risk of later AMD inception (and unplanned expenses…)

http://www.fcci.com.au/category/mining/

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Thank you

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