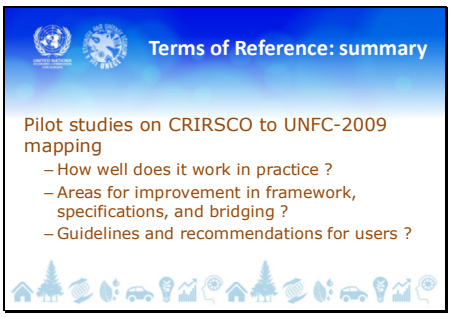
Slide 1

Slide 2



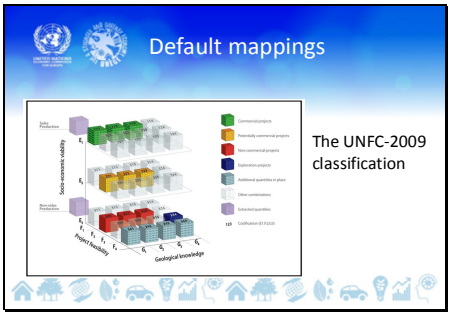
The 3 main purposes of the study are:

* how well does the bridging work in practice?

* what areas of improvement or modification in framework, specifications, and bridging?

* guidelines for users

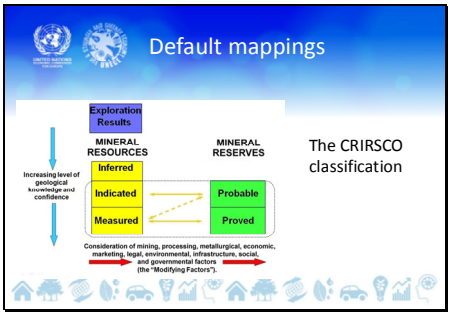
Slide 3



Let's start by looking at the standard defined mappings between CRIRSCO and UNFC-2009 classifications

This is the UNFC-2009 cube …

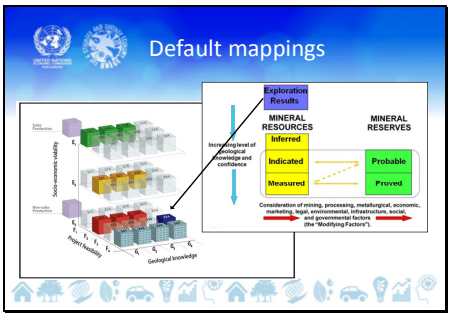
Slide 4



… and the CRIRSCO classes.

Although this is the classification, it is part of a more general set of reporting standards.
Currently there are seven CRIRSCO-aligned standards recognised in different jurisdictions, for public reporting by minerals companies.
All use the same classification and an identical set of standard definitions
The scope of CRIRSCO is **all solid minerals**
This classification shows increasing geological knowledge downwards, and increasing knowledge of socio-economic and technical modifying factors towards the right

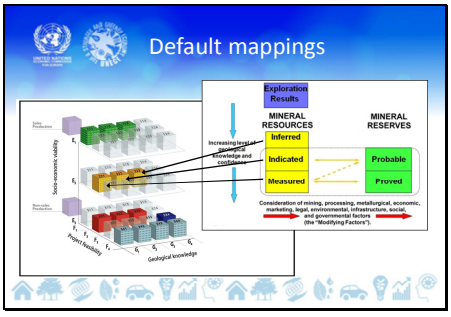
Slide 5



This is the DEFINED MAPPING between them

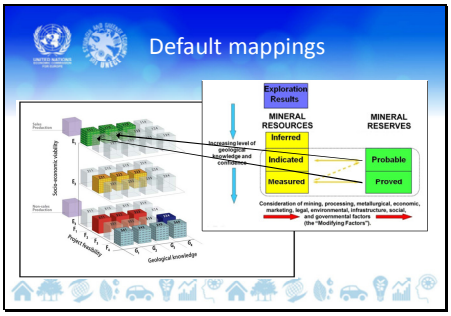
– first for Exploration Results (and Exploration Targets)

Slide 6



Then for the CRIRSCO classes of MINERAL RESOURCES

Slide 7



Finally for the CRIRSCO classes of MINERAL RESERVES

Slide 8

In November 2013 a revised version of the CRIRSCO Template was published.
Significant changes relevant to this report are:

New agreed standard definitions to be used in all CRIRSCO standards. These include

- **Effective Date** and **Reference Point** definitions added, to harmonise with UNFC-2009
- **Exploration Target** definition to harmonise with CRIRSCO standards
- **Feasibility Study, Pre-feasibility Study, and Scoping Study** definitions added

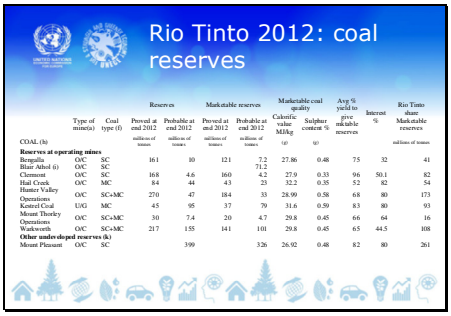
Slide 9

A number of case studies were selected to cover a range of different types of mineral,

to include data from exploration and mining companies,

and both public listed companies and private companies.

Slide 10



To start with …. An international public company – RIO TINTO – data from their 2012 published annual report.

We'll start by looking at some of the published data on COAL RESERVES (and then go on to look at the RESOURCES).

Slide 11

Different reference points –

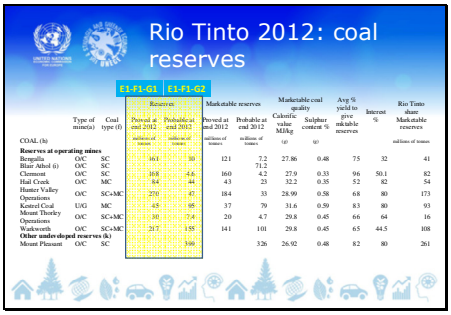
- **Reserves** are at delivery to the **processing plant**;

- **Marketable Reserves** are after processing, at **point of sale**, these are commonly estimated based on averaged processing yields rather than actual measured numbers.

Of the two, it is NOT mandatory to report **Marketable Reserves**; conventionally only **Reserves** are required.

If data are to be aggregated, ALWAYS use the **Reserves** estimates.

Slide 12



So here is the mapping –

Proved Reserves are mapped to 111
and
Probable Reserves are mapped to 112

Slide 13

Most of the data are about Reserves at operating Mines.

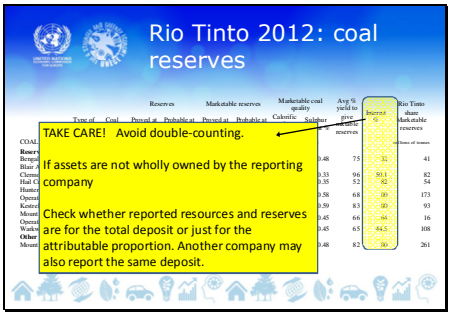
But one line refers to "other undeveloped reserves".
Footnote (k) in the report explains what these are.

Slide 14

Permits are not yet in place and may not be obtained.

They clearly fall into the sub-class E1.1 – F1.3 – G2.
E1.1 = economic (otherwise they wouldn't be Reserves)
F1.3 = development not yet underway – awaiting permits

Slide 15



A trap for the unwary.

Always CHECK whether figures quoted are for the WHOLE deposit or for the PROPORTION owned by the reporting company
Data may be recorded in different ways by different companies.

Different joint venture participants may even have different estimates for the total reserves and resources on the same deposit.

Slide 16

Now for RESOURCES.
This is for material in the ground, for which detailed mine planning studies have not yet been done.

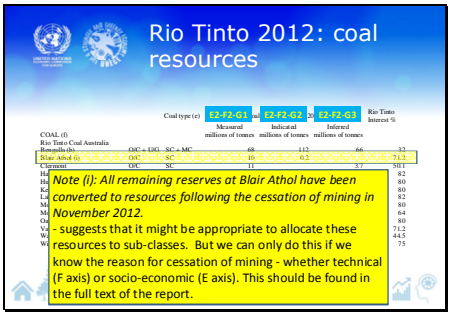
There are reasonable prospects for eventual economic extraction

Slide 17

The standard mappings are straightforward

Measured resource to 221
Indicated resource to 222
Inferred resource to 223

Slide 18



Footnote (i) in the report states that mining at Blair Athol has ceased. **Resources** quoted here have been downgraded from material previously reported as **reserves**

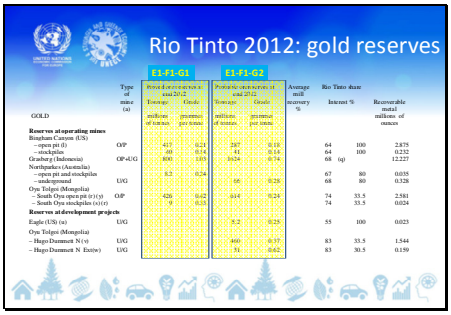
We may be able to allocate these resources to sub-classes if there is further information in the text of the report to explain the circumstances.

Slide 19

Rio Tinto again – **gold** reserves and resources.

We'll start with the Reserves table.

Slide 20



Here we have not just tonnages but **tonnages and grades**, as the proportion of contained gold will vary from one deposit to another, and from place to place within one deposit.

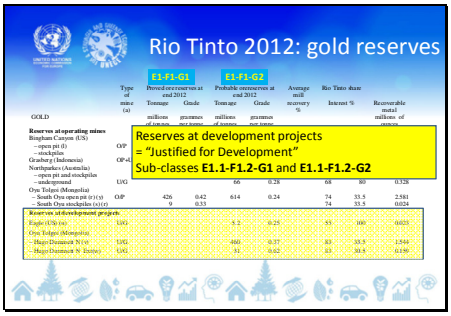
The standard mapping is still simple – but each Reserve estimate is now a pair of numbers TONNAGE and GRADE from which you can estimate an amount of contained metal in ore that will be delivered to the processing plant.

Slide 21

For the "Reserves at Operating Mines", according to the guidelines in Annex V,

these are "On Production" and the reserves may be allocated to sub-classes E1.1-F1.1-G1 and E1.1-F1.1-G2 respectively.

Slide 22



For the "Reserves at Development Projects", these are **justified for development.**

F1.2 if capital is already committed

Slide 23

If there is evidence in the Notes that all approvals have **not** been received and capital is not already committed, then they should be **F1.3**.

This could probably be answered from the context, in the body of the company's report.

Slide 24

Here is an example where – even though Rio Tinto generally reports reserves and resources for the TOTAL deposit,

in this case ONLY the attributable proportion is reported.

ALWAYS necessary to check the footnotes !!

Slide 25

Gold **Resources**.

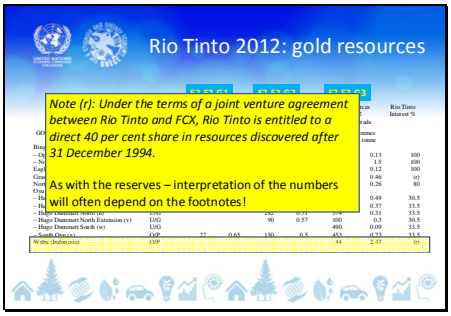
Simple standard mapping.

221 222 223

Slide 26

Again – note that some of these estimates refer to joint ventures

Slide 27



Here again the footnote tells us that only the attributable proportion is reported.

Slide 28

URANIUM **reserves** now.

Simple allocation to main classes

111 and 112

Slide 29

Be careful !

Slide 30

This line refers to STOCKPILED MATERIAL – already mined, but not yet processed.

Usually material in stockpiles would be considered as Proved Mineral Reserves, because all geological factors are known (the material has been mined) and all Modifying Factors are taken fully into account.

However, the Ranger#3 stockpiles are listed as partly Probable Mineral Reserves and partly Indicated Mineral Resources.

There may be some doubt over the economics of processing this material. Or it is possible that there may also be questions over some of the other Modifying Factors (such as environmental or social).

It is likely that the material should be allocated to lower sub-classes, such as E1.2-F2.2-G1 (for the Probable Reserves)

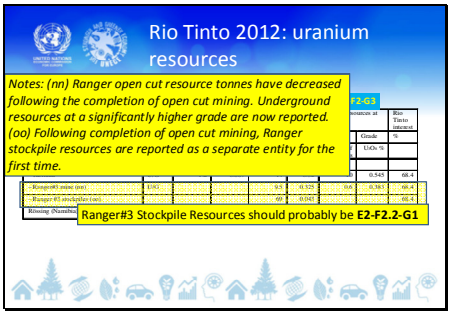
- **F2.2 'project on hold'**

Slide 31

Standard mappings of main classes of RESOURCES

221 222 223

Slide 32



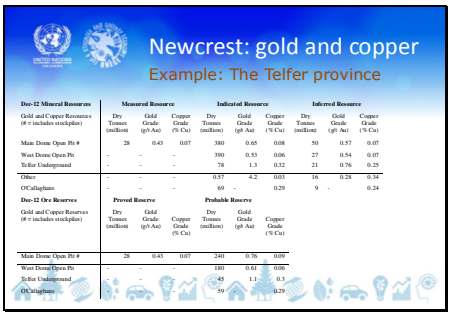
F2.2 – The Ranger #3 stockpiles again

'project activities are on hold …'

If this really is stockpiled material that has already been mined, then it should be **G1**.

The downgrading to a CRIRSCO Indicated Resource is probably a result of doubt over Modifying Factors, as with the Reserves for the same stockpiles.

Slide 33

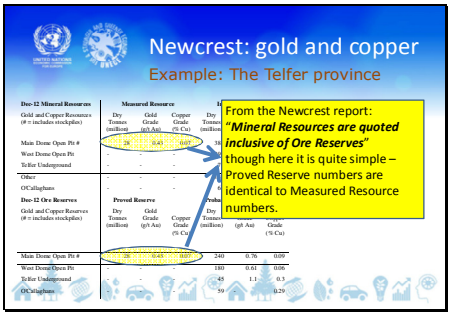


Different company now - NEWCREST

Now on to the situation of multiple mineral products from the same deposit. Here, for simplicity, just gold and copper.

But there is also one further complication in this report from Newcrest.

Slide 34

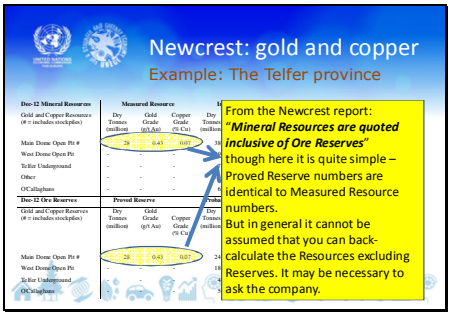


From their annual report, introduction to the reserves and resources tables: "***Mineral Resources are quoted inclusive of Ore Reserves***"

We can see this clearly in that the Proved Reserve uses up all of the Measured Resource.

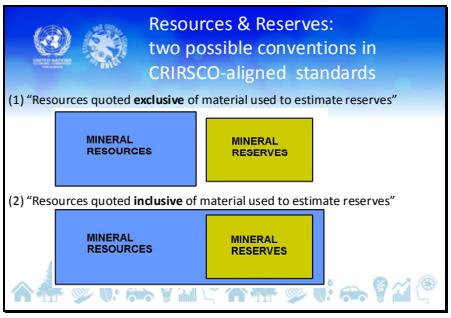
In UNFC-2009, data in all classes is exclusive of all others, **so we must take care not to double count**.

Slide 35



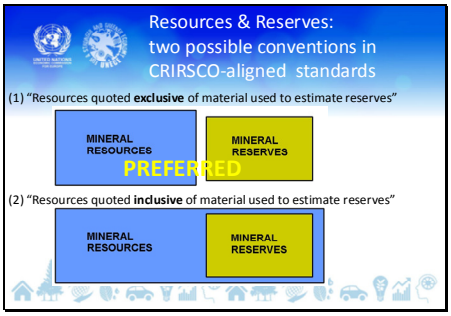
Unless explicitly quoted, it **cannot be assumed that you can back-calculate Resources** from the Reserves estimates.

Slide 36



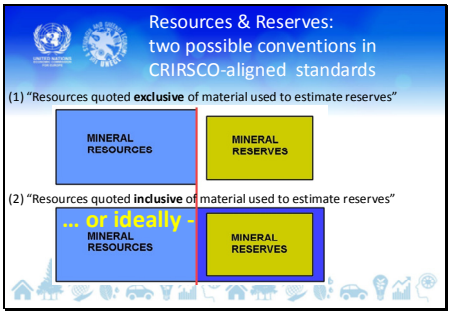
In CRIRSCO, it is allowed to report resources and reserves in two ways – BUT it must always be specified which convention is being used.

Slide 37



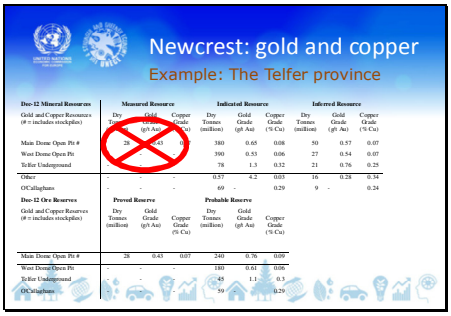
Although it is preferred that resources be quoted EXCLUSIVE of reserves, some companies use the other convention.
Newcrest is one of these companies.

Slide 38



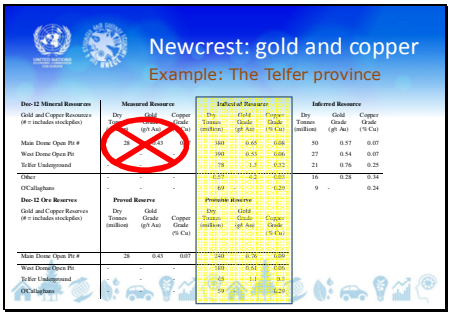
Ideally, all of the quantities should be quoted to make it quite explicit what has been done.
So the dark blue area represents mineral resources which have been used to estimate the mineral reserves.

Slide 39



The Measured Resource is fully used up in defining the Proved Reserve and so it must not be counted separately.

Slide 40

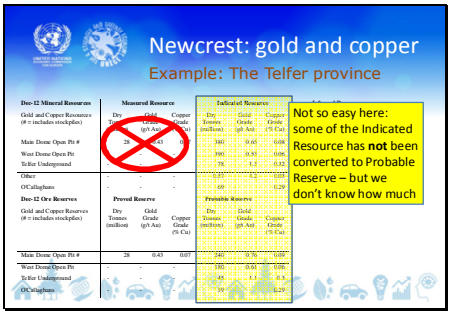


The Indicated Resource is PARTIALLY used in defining the Probable Reserve –

so must be recalculated (if this can be done using the reported estimates)

to give a separate figure for the Resource, to avoid double counting of the amount used for Reserves..

Slide 41

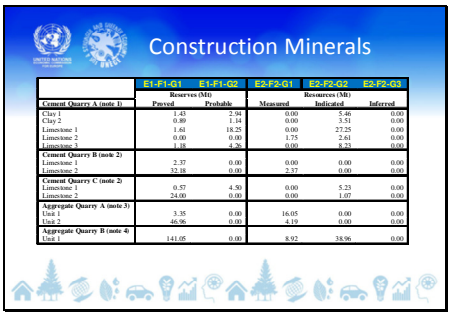


If there is not sufficient data in the Tables or in the body of the report to allow such re-calculation, the data must be sought from the company.

NOTE THAT it is not in general sufficient simply to back-calculate using dilution and loss factors, because some resources might have been excluded from the mine design.

The assignment of UNFC classes is simple once we have these numbers.

Slide 42



	E1-F1-G1	E1-F1-G2	E2-F2-G1	E2-F2-G2	E2-F2-G3
	Reserves (Mt)		Resources (Mt)		
Cement Quarry A (note 1)	Proved	Probable	Measured	Indicated	Inferred
Clay 1	1.43	2.94	0.00	5.46	0.00
Clay 2	0.80	1.14	0.00	3.51	0.00
Limestone 1	1.61	18.25	0.00	27.25	0.00
Limestone 2	0.00	0.00	1.75	2.61	0.00
Limestone 3	1.18	4.26	0.00	8.23	0.00
Cement Quarry B (note 2)					
Limestone 1	2.37	0.00	0.00	0.00	0.00
Limestone 2	32.18	0.00	2.37	0.00	0.00
Cement Quarry C (note 2)					
Limestone 1	0.57	4.50	0.00	5.23	0.00
Limestone 2	24.00	0.00	0.00	1.07	0.00
Aggregate Quarry A (note 3)					
Unit 1	3.35	0.00	16.05	0.00	0.00
Unit 2	46.96	0.00	4.19	0.00	0.00
Aggregate Quarry B (note 4)					
Unit 1	141.05	0.00	8.92	38.96	0.00

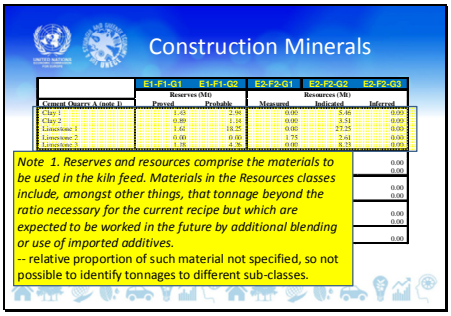
Now to look at **Construction Minerals**

– cement raw materials and aggregates

This table is real sample data from an internationally operating cement and aggregates producer.

Simple assignment of UNFC classes to these reserves and resources is shown at the top of the columns.

Slide 43

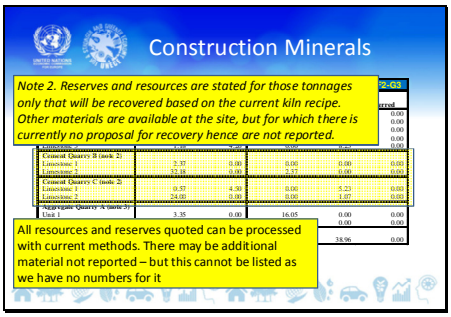


CEMENT QUARRY "A"
Not all of the Resources can be used with the processing method currently in use.

However, they could be used later, with modified processing methods. There ARE reasonable prospects for eventual economic extraction.

Because the relative proportions are not specified, we cannot subdivide the classes.

Slide 44

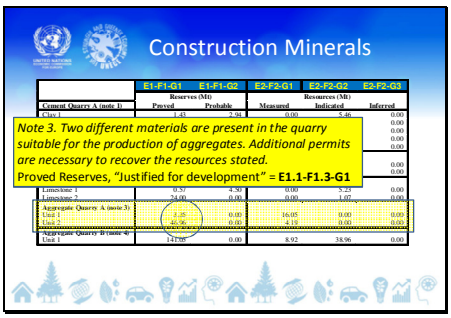


CEMENT QUARRY "B"
"Other materials are available at the site"
Material that is not reported does not have “reasonable prospects for eventual economic extraction” and therefore cannot be assigned to any CRIRSCO class.

In theory it could be reported in UNFC as recoverable uneconomic.

However, it is of no current interest to the company and therefore there may not be any usable estimates

Slide 45

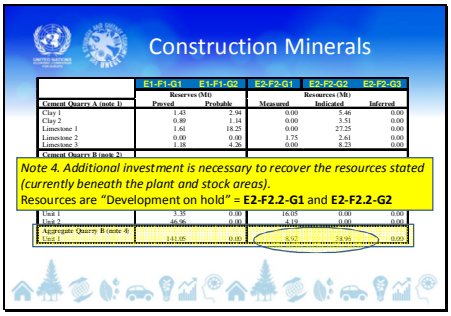


In **Aggregate Quarry "A",**

the reported reserves cannot be extracted yet because not all required permits are in place.

These therefore qualify for the sub-class 'Justified for Development', **F1.3**

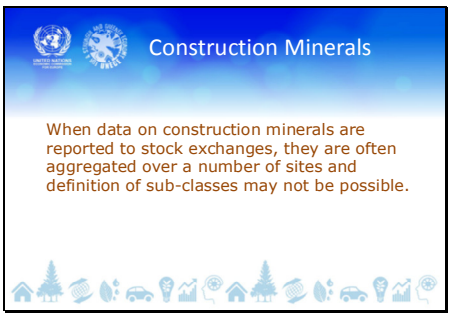
Slide 46



The Resources identified for **Aggregate Quarry B** are not currently accessible.

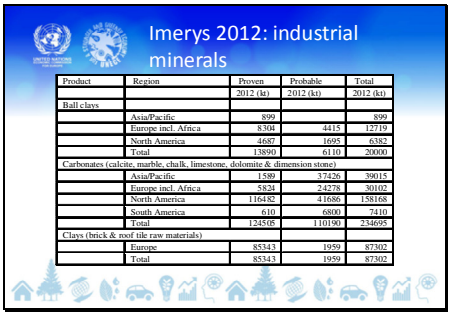
These would be identified as 'development on hold', with a corresponding F sub-class of **F2.2**

Slide 47



Data are often aggregated over many sites - and definition of sub-classes may not be possible or appropriate

Slide 48



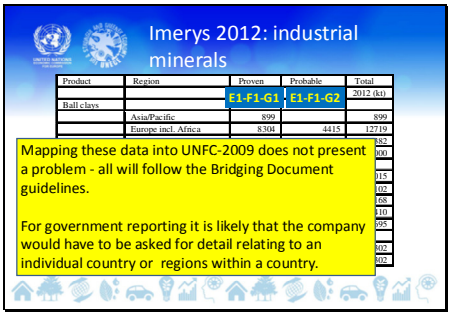
Product	Region	Proven	Probable	Total
		2012 (kt)	2012 (kt)	2012 (kt)
Ball clays				
	Asia/Pacific	899		899
	Europe incl. Africa	8304	4415	12719
	North America	4687	1695	6382
	Total	13890	6110	20000
Carbonates (calcite, marble, chalk, limestone, dolomite & dimension stone)				
	Asia/Pacific	1589	37426	39015
	Europe incl. Africa	5824	24278	30102
	North America	116482	41686	158168
	South America	610	6800	7410
	Total	124505	110190	234695
Clays (brick & roof tile raw materials)				
	Europe	85343	1959	87302
	Total	85343	1959	87302

This is a classic example, from the **IMERYS annual report for 2012.**

These data are aggregated across supra-national regions.

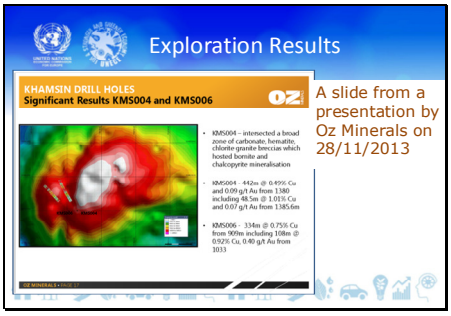
Such aggregation of data is allowed in the CRIRSCO-aligned PERC Standard 2013, for consistency with the ESMA regulations, provided that the company retains full Competent Person reports for each site or each geographical group of sites.

Slide 49



The CRIRSCO to UNFC mapping for such data is simple – but for government reporting the company may be asked to supply the underlying data on separate sites.

Slide 50

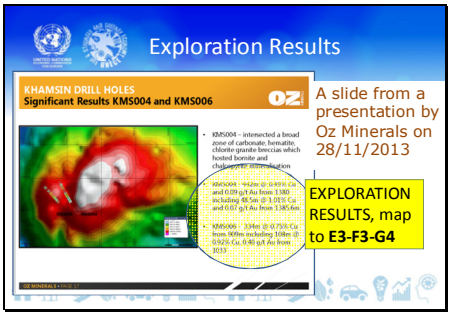


Now to look at **EXPLORATION DATA**

First – **Exploration Results**. These are raw data from drilling, geochemical, geophysical, or any other mineral exploration methods

The CRIRSCO definition is:
Exploration Results include data and information generated by mineral exploration programmes that might be of use to investors but which do not form part of a declaration of Mineral Resources or Mineral Reserves.
These are mapped to UNFC-2009 class 334
.
Oz Minerals is a small Australian exploration company listed on the Australian Stock Exchange.

Slide 51

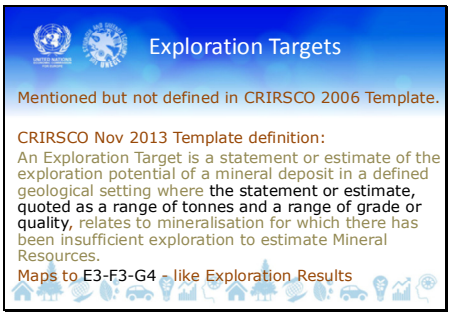


Of the three items on this page, the first is purely descriptive and probably would not normally be considered as 'Exploration Results' – though it does fall within the CRIRSCO definition as it is "information".

The second and third items contain quantitative data which would constitute Exploration Results and would map to the UNFC-2009 class E3-F3-G4.

It must be noted that these are purely drill hole data, and cannot be related to any estimated tonnage or any estimate of average grade. They do not represent resources, but are merely publication of preliminary data which might (or might not) later be used to estimate a mineral resource.

Slide 52

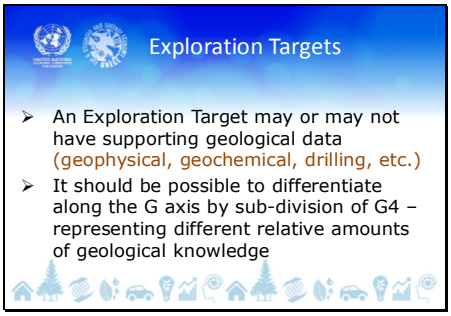


EXPLORATION TARGETS

These were originally defined in JORC 2004, and briefly mentioned in the CRIRSCO 2006 Template.

A full definition was provided in the CRIRSCO 2013 Template in order to control (and prevent the misuse) of this term.

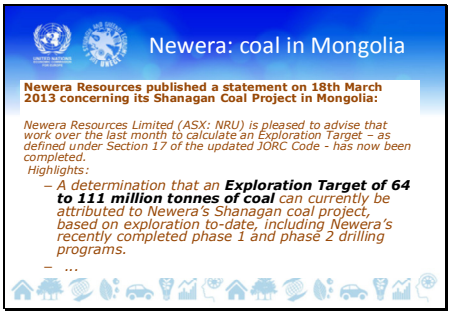
Slide 53



A CRIRSCO Exploration Target quite clearly maps to the UNFC class E3-F3-G4.

It ought to be possible to use G-axis sub-classes to differentiate it on the basis of relative amounts of supporting geological information.

Slide 54



Data from a COAL EXPLORATION project in Mongolia

This is a simple range of coal tonnages.

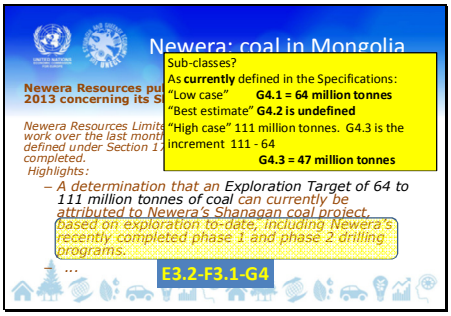
Slide 55

E AXIS: Exploration phase – insufficient economic information, so would be E3.2

F AXIS: Because some site-specific geological information is available, this would map to F3.1 under current Specification R

– though it is illogical to use the F axis for subdivision on the basis of geological knowledge.

Slide 56

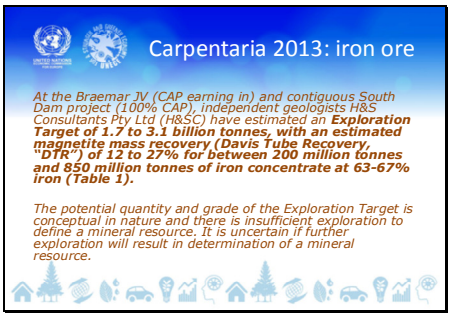


G AXIS: Under the current Specification P
… it could be mapped to G4.1 for the lower limit and G4.3 for the upper limit (well actually the difference between upper and lower – G4.2 and G4.3 are defined as increments)

G4.2 best case would be undefined. **Cannot be zero** because this implies that the lower limit is also the best case.

However, in my view this is an inappropriate way to subdivide the G axis, as all elements of a range have the same degree of geological uncertainty.

Slide 57



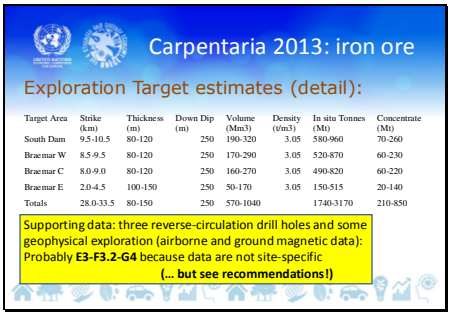
A different company now - and IRON ORE EXPLORATION DATA

As an Exploration Target, assignment to 3 3 4 is clear.

Can we assign to sub-classes?
The ranges here are in terms of both **tonnage** and
grade expressed as a magnetite recovery factor.

The company goes further and identifies five separate exploration targets which are combined in these figures……

Slide 58

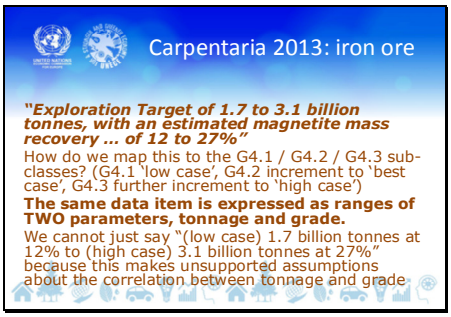


Three drill holes to estimate the potential in FIVE exploration areas.

Assignment to UNFC-2009 sub-classes is problematic.

As we have just seen, mapping to an F3 sub-class (in this case F3.2) is wrong because **the F axis is here being used for relative amounts of GEOLOGICAL knowledge** - should be a G4 sub-class.

Slide 59



Worse still, on the G axis -- the Exploration Target is expressed as TWO ranges, of **tonnage** AND **grade**. These don't map to the G4.1 / G4.2 / G4.3 sub-classes as defined in Specification P.

These G4 sub-classes are not usable even if we allow ourselves to leave the 'best case' value undefined – because there are TWO ranges of different parameters (tonnage and magnetite content) – and in general there could be any number of ranges for different mineral components.

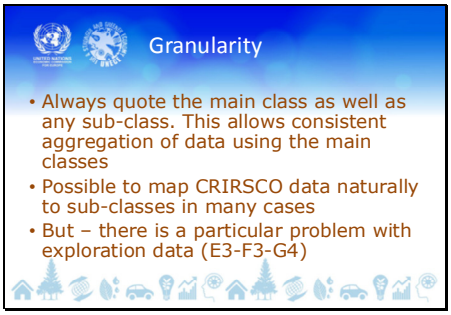
Slide 60

It would be wrong to put all of the lower limits into a G4.1 class and all of the upper limits into a G4.3 class because this could be taken as implying perfect positive correlation among the different parameters.

Slide 61

What we have learned ....

Slide 62

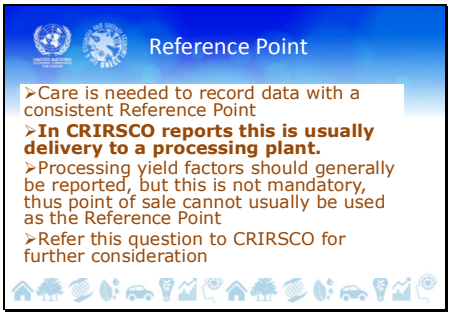


It is (almost) always possible to assign a main UNFC class, given a CRIRSCO class. In some cases it could be necessary to ask a company for extra information, for example where Resources have been quoted INCLUSIVE of material used to define Reserves, or where data have been aggregated over multiple sites in different regions or different countries.

It is sometimes possible also to define a natural mapping to sub-classes .

A particular problem has been identified in that the F and G axis sub-divisions for Exploration Data require some re-definition. This will be discussed as a separate issue.

Slide 63



Reference point requires care – a particular example in this report is Coal Reserves and Marketable Coal Reserves.

CRIRSCO standards require that Coal Reserves (delivered to processing plant) always be reported, estimates of marketable reserves are optional, and, although recommended, it is not mandatory to quote processing yield factors in a CRIRSCO report.

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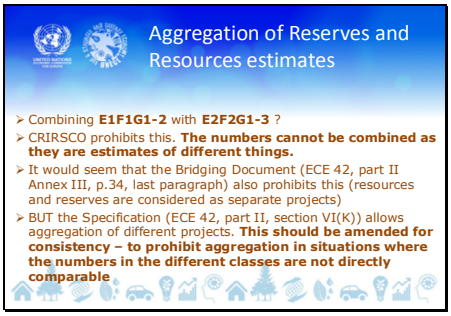
if time allows -

Possible standardisation on a point-of-sale reference point has been discussed before in CRIRSCO but the question should be given further consideration.

One problem is that it requires mandatory inclusion of processing yield factors, something which many companies do not currently quote, and which could be a particular problem for industrial minerals companies where the same source mineral can lead to several alternative end-products as a result of blending or different processing paths.

The yield factors in such circumstances may indeed be trade secrets which the companies will resist pressures to disclose.

Slide 64



GREAT CARE IS NEEDED WHEN AGGREGATING DATA

We may have Estimates of different things:-

CRIRSCO definitions include:

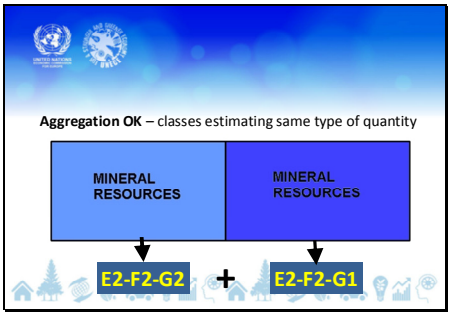
A Mineral Resource is a quantity of mineral which has **"reasonable prospects for eventual economic extraction."**

A Mineral Reserve is **"the economically mineable part of a Measured and/or Indicated Mineral Resource"** on which assessments at feasibility or pre-feasibility level "demonstrate at the time of reporting that extraction could reasonably be justified".

A Reserve will in general include only part of a Resource – within a defined mine design, and after allowance for dilution and mining losses.

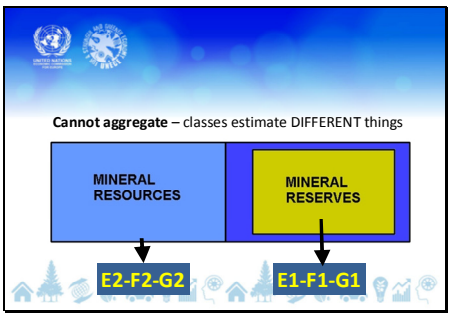
Resources cannot in general be back-calculated from Reserves.

Slide 65



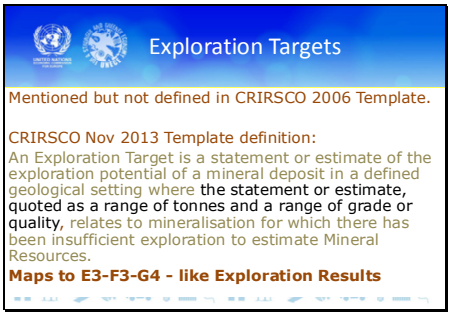
Two sets of mineral resources can be added together

Slide 66



But it is wrong to add mineral resources and reserves together.

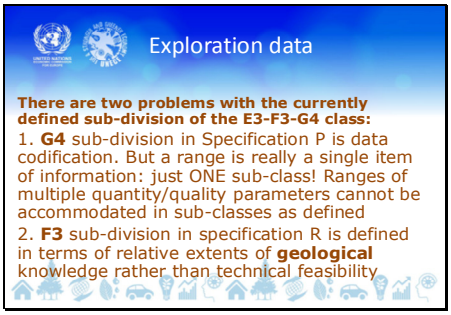
Slide 67



As already seen. This is a new definition in the CRIRSCO 2013 Template – but is a formalisation of something that was already defined in the 2004 JORC Code.

They map to 3 3 4 just like Exploration results.

Slide 68

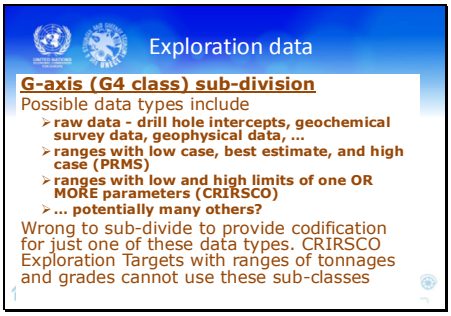


Now to the problems with subdividing the 334 class.

G AXIS: A range of values (or multiple ranges of several parameters) represents data from just a **single level of geological uncertainty** and should all be included within a SINGLE sub-class along the G axis. Separate sub-classes G4.1, G4.2, and G4.3 as defined in Specification P might wrongly be seen as expressing different degrees of knowledge.

F AXIS: The F sub-division defined in the Specification R is purported to represent 'project maturity' but **ACTUALLY expresses different degrees of geological knowledge**.

Slide 69



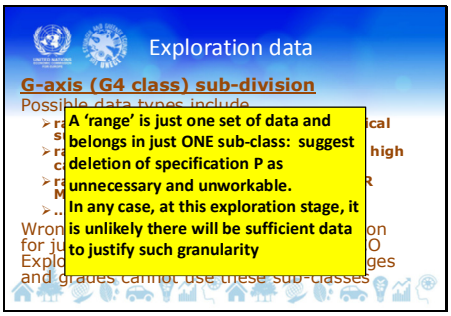
Let's look at the G axis (specification P) first.

There are many different ways to represent exploration information. It is not appropriate or even feasible to define sub-divisions to allow each of these data types to be codified in UNFC-2009,

and it is not appropriate to define a set of sub-divisions which are specific to the requirements of a single sector of the extractive industry.

Sub-division along the G-axis should represent just differing relative amounts of geological knowledge.

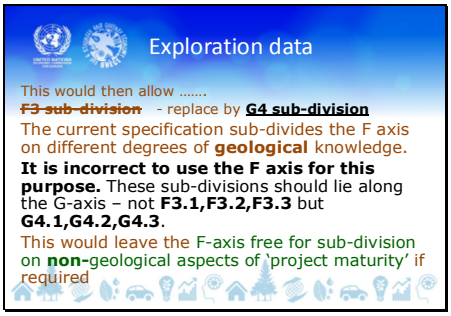
Slide 70



All the numbers associated with a range, or other kinds of data, will fall within just ONE sub-class.

We should not split out elements of a range into different sub-classes. All have the same degree of geological knowledge.

Slide 71



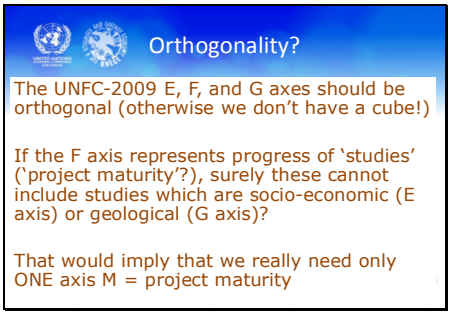
Now for the F axis (specification R)

Relative stages of "project maturity" will involve changes in the underlying factors on **all three axes** E, F, and G, and **any sub-divisions should be done along the appropriate axis.**

For changes in the relative amount of geological knowledge, surely that is the G axis ?

This would leave the F axis free for NON-geological aspects of project maturity

Slide 72

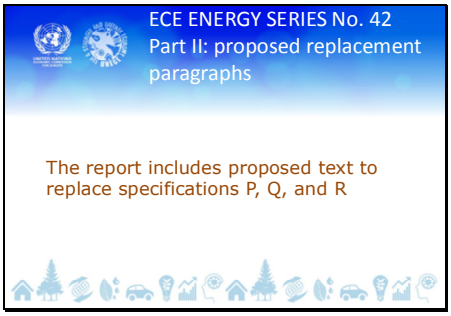


This raises the issue of ORTHOGONALITY.
This is a question that is fundamental to the UNFC-2009 structure.

The E, F, and G axes must be orthogonal.
This means that we can't map geological knowledge sometimes along G and other times along F.

If the 'project maturity' concept were to be considered as fundamental then maybe we need only one axis M to replace all three ?

Slide 73

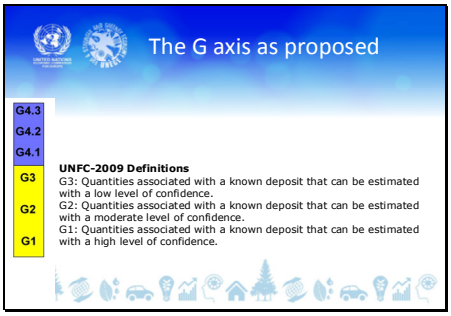


I have suggested replacements for Specifications P, Q, and R --
-- but personally I think at an early exploration stage there is unlikely to be enough data to justify ANY subdivision.

Subdivision of 334 gives a false sense of precision.

The best option might be simply to delete specifications P, Q, and R

Slide 74

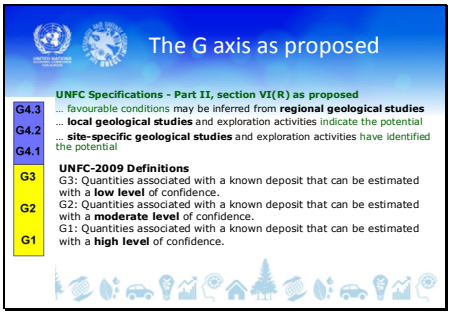


However ---

Just to illustrate what I proposed in the report, here is a new G axis mapping from CRIRSCO to UNFC-2009.

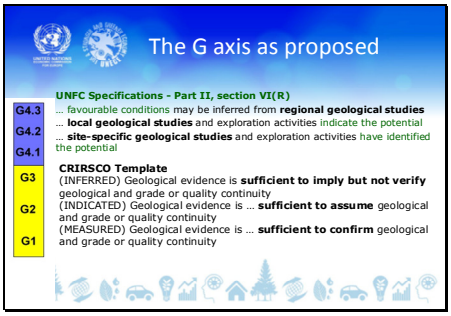
First the G1, G2, G3 standard definitions in UNFC

Slide 75



Now the proposed replacement definitions in specification R

Slide 76

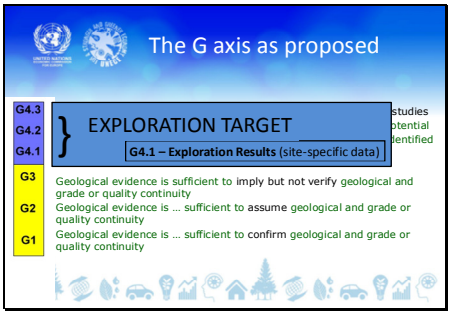


The CRIRSCO classes which map to the G1, G2, and G3 classes

Slide 77

The CRIRSCO Exploration Target which maps to G4 and its sub-classes

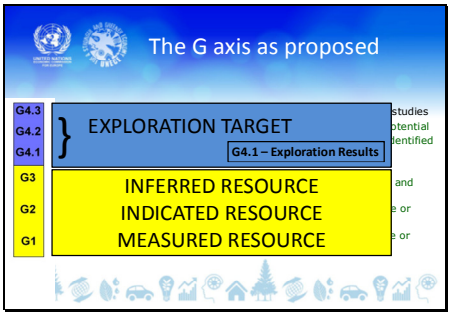
Slide 78



Exploration results neatly fit into the proposed G4.1 sub-class

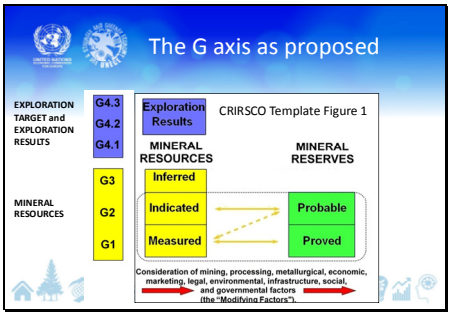
(this is F3.1 in the current specification R)

Slide 79



All of the CRIRSCO classes

Slide 80



- And this is how it fits with the CRIRSCO standard Figure 1.

Slide 81

A brief summary of other conclusions …..

- The mapping is not automatic. It does need Competent Person validation –

Slide 82

- Competent Person – where not already required,

- should either be required within companies -- or (better) provide a government CP to validate data from all sources – listed and unlisted companies, geological surveys, universities, research institutes, etc.

- It may be of interest that this matches one of the key recommendations from Anne-Sophie Audion of BRGM, in the European Union MINVENTORY project

Slide 83

Data formats. Not prescribed in UNFC, but minerals resource/reserves databases need careful design. Separate database columns, for UNFC class (allows aggregation), and UNFC sub-class if needed.

Avoid double-counting if CRIRSCO reports quote estimated resource INCLUSIVE of reserves

Avoid possible double-counting when recording data from joint ventures. Need unambiguous identification of projects

Take care if aggregating data with different cutoff grades – using different economic models **OR at different dates** (example – a 2007 project forecast probably won't be comparable with a 2009 project forecast!)

Slide 84

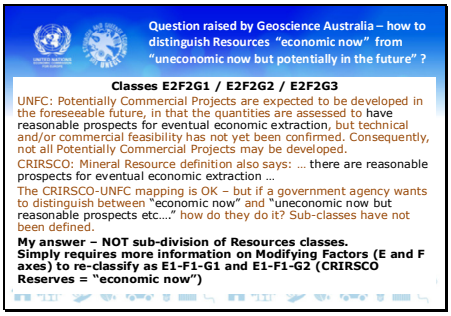
some more conclusions …..

For undiscovered / uneconomic / unrecoverable – better not to use company data, likely to be incomplete and unreliable. Use geological survey estimates instead

CRIRSCO Reserve estimates allow for dilution and losses. CRIRSCO Resource estimates are mineral in the ground. **Do not aggregate them. This needs to be written into the Specifications.**

Always use the same reference point, for each type of mineral. Usually this will be delivery to a processing plant, though for some minerals which require no processing it could be point of sale.

Slide 85



Geoscience Australia have raised a question, on how to distinguish resources that are "economic now" from resources that are "uneconomic now but potentially economic in the future".
This is one area where there is actually a word-for-word match between UNFC and CRIRSCO definitions.

The answer is that it does not require any modifications.
"Economic now" should fall within one of the Reserves classes – but may need additional Modifying Factor data to decide which class.
For example, you can't use a Reserves class without having a mine plan (and without a mine plan you can't be sure that it is "economic now").

"Uneconomic now but potentially in the future" is simply saying "…reasonable prospects for eventual economic extraction " = Resources.

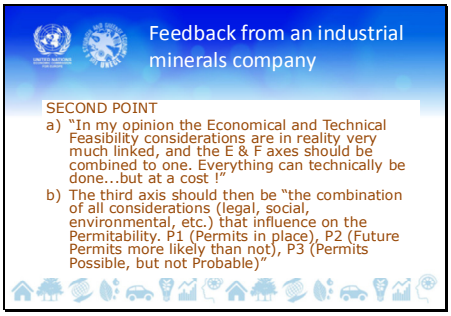
Slide 86

An industrial minerals company has raised a couple of questions.

The company has identified that in all of its current projects, the most critical factor in moving from resources to mining is **permitting**.

It doesn't lie obviously on any of the E, F, and G axes. Absence of permits leads to the same classes
for what they consider to be Reserves, as economic uncertainty in estimated Resources.

Slide 87



Their second point is that most of the socio-economic and technical parameters are not really orthogonal as they can be mapped to a single 'economics' axis (combined E and F).

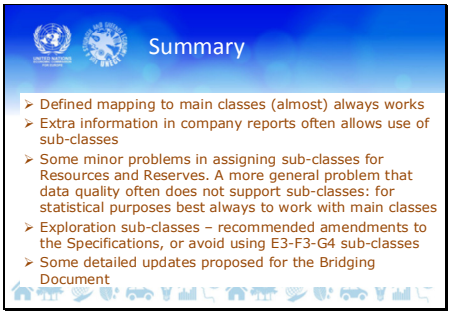
There would then be a third separate ("legal"?) axis which relates purely to permitting.

Slide 88

They give an example – two deposits with different constraints that map to the same UNFC class.

However, since neither of them would be considered as a Resource or Reserve in CRIRSCO, I am not sure if it's too realistic an example.

Slide 89



I would like to conclude with some general comments.

For government statistical purposes there will often be very variable data quality. Use of Competent Persons for professional quality control is something that I would strongly recommend.

Avoiding use of UNFC-2009 **sub-classes** will help – **the data quality will often not be good enough.**

Restricting consideration to CRIRSCO categories would make this simpler – thus governments can standardise on using appropriate CRIRSCO codes, with confidence that they can extract information to map to UNFC-2009 classes whenever they want.

The advantage is that CRIRSCO codes provide a complete set of principles for reporting, not included in UNFC. This project has provided a demonstration of how the mapping between the two can be done.

There are some detailed updates to the Specifications and Bridging Document which I have identified as necessary, but my own view is that much grief could be avoided simply by not trying to use sub-classes anywhere. **The standard mapping between CRIRSCO and UNFC-2009 main classes works pretty well.**

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Slide 91