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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

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

This is the UNFC-2009 cube ...



... and the CRIRSCO classes.

Although this is the classification, it is part of a more general set of reporting standards. Currently there are seven CRIRSCOaligned 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 socioeconomic and technical modifying factors towards the right

This is the DEFINED MAPPING between them

– first for Exploration Results (and Exploration Targets)

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Then for the CRIRSCO classes of MINERAL RESOURCES



Finally for the CRIRSCO classes of MINERAL RESERVES

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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

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.



				i v C	5					
		Rest	erves	Marketabl	le reserves	Marketa	ible coal ăty	Avg % yield to		Rio Tint
ype of tine(a)	Coal type (f)	Proved at end 2012	Probable at end 2012	Proved at end 2012	Probable at end 2012	Calorific value MIAv	Sulphur content %	give mktable	%	Mark etab reserves
		millions of	millions of	millions of	millions of	60	60			millions of to
ag miner		and an	10.00.0	and a	and a second					
AC AC	SC SC	161	10	121	7.2	27.86	0.48	75	32	
AC DC	SC MC	168	4.6	160	4.2	27.9	0.33	96 52	50.1 82	
AC	SC+MC	270	47	184	33	28.99	0.58	68	80	
JVG	MC	45	95	37	79	31.6	0.59	83	80	
λС	SC+MC	30	7.4	20	4.7	29.8	0.45	66	64	
ж	SC+MC	217	1.55	141	101	29.8	0.45	65	44.5	
reserves DC	3 (k) SC		399		326	26.92	0.48	82	80	
	pe of inc(a) g mines VC AC AC AC AC AC AC AC AC AC AC AC AC AC	pe of Coal ine(a) type (f) g mines NC SC NC SC NC MC NC SC+MC NC SC+MC NC SC+MC NC SC+MC NC SC+MC NC SC+MC NC SC+MC	Rest res of Crail Proved as res of type (0) Proved as res of type (0) Proved and res of the rest of the res of the res res of the rest of the res of the res res of the rest of the res of the res res of the rest of the res of the res res of the rest of the res of the res rest of the res of the res of the res rest of the res of the res of the res rest of the res of the res of the res of the res rest of the res of th	Receive a point of coll Receive a point/of coll gradie ender of coll ender of coll gradie </td <td>Parties Markability grad Dend and type in the interval and type in the interval and the interval and</td> <td>Reserve Maddatist servers graf (yes) Parad a Pachaka (yes) Parad a Pachaka (yes) Pachaka (yes) graf Barad (yes) Barad (yes) Barad (yes) Barad (yes) graf Barad (yes) Barad (yes) Barad (yes) Barad (yes) GC SG Hd Barad (yes) Barad (yes) Barad (yes) GC SG Hd 46 Hd Barad (yes) Barad (yes) GG MC SG Hd 46 Hd Barad (yes) GG MC SG Hd Hd Barad (yes) Hd Barad (yes) GG MC SG Hd Hd Barad (yes) Hd Barad (yes) GG MC SG Hd Hd Barad (yes) Hd Barad (yes) GG MC SG Hd Hd Barad (yes) Hd Hd Barad (yes) Hd Hd Barad (yes) Hd Hd Barad (yes) Hd Hd</td> <td>Reserve Matadalia conserve Matadalia conserve</td> <td>Bourns Makadala nerus Makadala nerus<</td> <td>Rosers Madazile results Angle units Angle Status Angle Status<td>Rearry Madazibit results Maging unity Maging Figure Maging Figur</td></td>	Parties Markability grad Dend and type in the interval and type in the interval and	Reserve Maddatist servers graf (yes) Parad a Pachaka (yes) Parad a Pachaka (yes) Pachaka (yes) graf Barad (yes) Barad (yes) Barad (yes) Barad (yes) graf Barad (yes) Barad (yes) Barad (yes) Barad (yes) GC SG Hd Barad (yes) Barad (yes) Barad (yes) GC SG Hd 46 Hd Barad (yes) Barad (yes) GG MC SG Hd 46 Hd Barad (yes) GG MC SG Hd Hd Barad (yes) Hd Barad (yes) GG MC SG Hd Hd Barad (yes) Hd Barad (yes) GG MC SG Hd Hd Barad (yes) Hd Barad (yes) GG MC SG Hd Hd Barad (yes) Hd Hd Barad (yes) Hd Hd Barad (yes) Hd Hd Barad (yes) Hd Hd	Reserve Matadalia conserve Matadalia conserve	Bourns Makadala nerus Makadala nerus<	Rosers Madazile results Angle units Angle Status Angle Status <td>Rearry Madazibit results Maging unity Maging Figure Maging Figur</td>	Rearry Madazibit results Maging unity Maging Figure Maging Figur

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).

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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.

So here is the mapping -

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

SI	Ide	12
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			R	io T eser	int ve	:o 2 s	01	2:	coa	al	
			Rele	Net Statist	Marketabl	e reserves	Market	able coal	Avg %		Rio Tinto
	Type of mine(a)	Coal type (f)	Proved at end 2012	Probable at end 2013	Proved at end 2012	Probable at end 2012	Calorific value MJ/kg	Sulphur content %	give mktable reserves	Interest %	share Mark etable reserves
COAL (b)			Nellencel Nelle	selfore.of	millions of longes	millions of loomes	60	60			millions of tonnes
Reserves at oper Bengalla Rhin Athal (i)	ating mins	SC	161	30	121	7.2	27.86	0.48	75	32	41
Clemont Hail Creek	O/C O/C	SC MC	168 84	12	160 43	4.2	27.9 32.2	0.33 0.35	96 52	50.1 82	82 54
Hunter Valley Operations	O/C	SC+MC	270	i i i i i i i i i i i i i i i i i i i	184	33	28.99	0.58	68	80	173
Kestrel Coal Mount Thorkey Operations	U/G O/C	MC SC+MC	45 30	195 7,4	37	79 4.7	31.6 29.8	0.59	83 66	80 64	93 16
Warkworth Other underelog	O/C ed reserve	SC+MC is (k)	217	155	141	101	29.8	0.45	65	44.5	108
Mount Pleasant	O/C	SC		399		326	26.92	0.48	82	80	261
	D.	0:	•	1	•		1	0		. 9	11 (*)



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.

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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

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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.



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

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HERE REAL	R r	lio T eso	Tinto urces	2012	: coa	al	
		Cool toma (a)	F2-F2-G1	F2-F2-G2	F2-F2-G3	Rio Tinto	
COAL (f) Bio Toto Coul Amstedia		courtype (c)	Measured millions of tomes	Indicated millions of tonnes	Inferred millions of tonnes	Interest %	
Bengalla (h)	$\Omega/C + UG$	SC + MC	68	112	66	32	
Blar Athol (i)	O/C	sc	10	0.2		71.2	
Clermont Hail Creak	OC OC	SC	11	20	3.7	50.1	
Hunter Valley Operations	00.4100	SC + MC	201	428	368	80	
Kentrel West	0/C	SC		106	33	80	
Lake Elphinstone	O/C	MC		120	42	82	
Mount Plasant	0/C + U/G	SC + MC	162	245	205	80	
Mount Thorley Operations (j)	0/C + U/G	SC + MC		19	94	64	
Ouklands	O/C	SC	596	584	90	80	
Valeria	O/C	SC		698	64	71.2	
Warkworth	0/C + U/G	SC + MC	6.2	125	343	44.5	
Winchester South	O/C	MC		17	175	75	
***	~	011	*	40	(): 🚗	921	٢

The standard mappings are straightforward

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

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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.



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

We'll start with the Reserves table.

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		EI-FI-GI	E1-F1-G2			
	Type	Proved or evenes at	Probable openographics at Av	erage Rio T	into share	
	mine	Torner Crode	200000000000000000000000000000000000000	nue las	erent %	Remarable
	(a)	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX	CONTRACTOR AND A DESCRIPTION OF	*		metal
GOLD		Conditions Consistence	millions contained			millions of
-		of timber per timbe	of some			OUBCEN
Reserves at operating mines		XXXXXXXXXX	XXXXXXXXXXXXXXX			
- open pit (1)	02		0.00100010.00100	64	100	2875
- stockniles		40 014	00011001000200	64	100	0.232
Grasberg (Indonesia)	OP+UG	800	0.000440000000040	68	(q)	12.227
Northparkes (Australia)		0001000100010	2010201001000100			
- open pit and stockpiles	1100	2226822622288	33342354332423	67	80	0.035
- unacigouna Des Talasi (Messalis)	uu	2221222122212	0.00192010.00192	65	80	0.328
- South Own open nit (r) (s)	0.2	476 0.47	AND AND A DOMESTIC	74	33.5	2 581
- South Oyu stockpiles (s)(r)		000100010000	00010001000100	74	33.5	0.024
Reserves at development proje	ctx	XXXEXXXEXXXE	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX			
Paule (US) (w)	TWG		100000000000000000000000000000000000000	55	100	0.023
Des Talani (Menantia)			201000100100			
The response of the rest of th	1100	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX	XXXXXXXXXXXXXXX			
- Hago Duminet N (V)	LIG	222122212212212	0,00100010,000000	83	33.5	1.344
 Hago Dummett N Ext(w) 	UG	XXXEXXXEXXXE	000013380013000380420	83	30.5	0.159

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.

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

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



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

F1.2 if capital is already committed

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	Type of mine	Proved ore end: Tonsuge	-G1 reserves at 2012 Gnide	Probable or end Teen age	1-G2 ereserves at 2012 Grade	Average mill necovery	Rio Tinto share Internet %	Recoverable
GOLD	(a)	millions	grammes	millions	grammes	- 9		metal millions of
- open pit (l) - stockpilos Grasberg (Indeensia) Northpackes (Australia) - open pit and stockpilos - underground Oyu Tolgoi (Mongolia) - South Oyu open pit (r) (5)	019 019+0 U/G 0.09	= "Justi Lower Possibl already	ified fo sub-cla y E1.1- / comr	or Deve asses E -F1.3-C nitted	lopme 1.1-F1 i1 and (or min	nt" .2-G1 a E1.1-F ning pe	ind E1.1- 1.3-G2 if rmits no	F1.2-G2 capital NOT t obtained)
- South Oyu stockpiles (x) (r)				A.I.A.I.A.I.A		CONTRACTOR INC.	XXXXXXXXXXX	XEXXXEXXEX
- South Oyu sinckpiles (x)(r) Ruser on at deteckeninger proj Eugen (US) (u)	ees GVC						10	0.023

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.

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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 !!



Gold Resources.

Simple standard mapping.

221 222 223

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

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

Uranium	Likely	E1-F1-	G1	Probable one	-G2	Rio
	mining method	end 2012		at end 2012		Tinto Interest
		Tonnage Millions of	Grade	Tonnage Millions of	Grade	%
Carrow Damage of Anotastic		tonnes	0308 %	tonnes	%	
(Australia)				73	0.132	68.4
Rössing (Namibia) (pp)	O/P	29	0.031	102	0.035	68.6
	Rio Ti reserv	n <mark>to 20</mark> /es)12: ι	uraniu	m	
		1.1.	61	1.1	-62	
Uranium	Likely	Proved ore re	serves at	Probable ore at and 2012	reserves	Rio
	method	Tomare	Grade	Tonnase	Grade	Interest
		Millions of	110 %	Millions of	10	<u>+</u>
Energy Resources of Australia	atch the a	attributa	ble per	centage	agair	<u>1</u>
– Ranger #3 stockpiles (00)				73	0.132	68.4
****	. 9 21	* *	40) (): F	•	
100 vil 900.	Rio Ti reserv	nto 20 /es) 12 : ι	uraniu	m	I Rio
Vote (oo): Following co. Ranger #3 reserves are with reduced tonnes an	mpletion o reported o d grade.	f open cu is stockpil	t mining es only,	Tobable ore	reserves	Tinto
Note (oo): Following co Ranger #3 reserves are with reduced tonnes an Probably should be E1 . explanation needed fro	mpletion a reported a d grade. 1-F2.2-G1 m report t	of open cu as stockpil but detail ext	t mining es only, ed	robable ore t end 2012 onnage	reserves Grade U₂O ₈ ⊛	Tinto Interest %

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URANIUM reserves now.

Simple allocation to main classes

111 and 112

Be careful !

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'



Standard mappings of main classes of RESOURCES

221 222 223

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@	Rio Tinto 2012: uraniu resources	um	
Notes: (nn) Ranger open following the completion resources at a significant (oo) Following completia stockpile resources are n first time.	cut resource tonnes have decreased of open cut mining. Underground ly higher grade are now reported. n of open cut mining, Ranger eported as a separate entity for the	72-53 Notaces at Grade F U.Ov % 0 0.545	Rio Tinto internet %
Rowing Namba Ranger#3 S	1995 Jack Construction Constraints and Constraints and Construction Constraints and Constraints	e E2-F2	.2-G1
****	. 9 21 ° A 📥 🔊 6 6	• 9	11 (*)

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.

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.

UNITED NATIONS			· · ·	ere.		501	au	101 0		
		Ex	am	ple:	The	Telf	fer p	rovi	nce	
Dec-12 Mineral Resources	Mea	ured Resou	rae	Indi	cated Resou	roe	Infe	rred Resour	100	
Gold and Copper Resources (# = includes stockpiles)	Dry Tonnes (million)	Gold Grade (g/t Au)	Copper Grade (% Cu)	Dry Tonnes (million)	Gold Grade (gh Au)	Copper Grade (% Cu)	Dry Tonnes (million)	Gold Grade (git Au)	Copper Grade (% Cu)	
Main Dome Open Pit #	28	0.43	0.07	380	0.65	0.08	50	0.57	0.07	
West Dome Open Pit	-			390	0.53	0.06	27	0.54	0.07	
Teller Underground	-			78	1.3	0.32	21	0.76	0.25	
Other			-	0.57	4.2	0.03	16	0.28	0.34	
OCallaghans	-			69		0.29	9		0.24	
Dec-12 Ore Reserves	Proved	Reserve		Probable	Reserve					
Gold and Copper Reserves (# = includes stockplies)	Dry Tonnes (million)	Gold Grade (p/t Au)	Copper Grade (% Cu)	Dry Tonnes (million)	Gold Grade (gt Au)	Copper Grade (% Cu)				
Main Done Open Pit #	28	0.43	0.07	240	0.76	0.09				
						0.04				



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**.

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	Ne Exa	wcre	est: gold and copper The Telfer province
Dec 12 Mineral Resources Gold and Copper Resources (# = includes stockpiles) Main Done: Open Pit # West Done: Open Pit Teller Underground Other O'Callaghans	Masured Resource Day Gold C Tomes Grade ((millios) (p)Au) C 28 840 	b Copper Day Tomose % Cu) (milion 007 38	From the Newcrest report: "Mineral Resources are quoted inclusive of Ore Reserves" though here it is quite simple – Proved Reserve numbers are identical to Measured Resource
Dec 12 Ore Reserves (# = includes stockpiles) Main Done: Open Pit # Wost Done: Open Pit Te for Underground OCallighums	Proved Reserve Day Gold Tomas Grade C (million) (ph Au) of	Copper Tomase St Cut (million 24 18	numbers. But in general it cannot be assumed that you can back- calculate the Resources excluding Reserves. It may be necessary to ask the company.

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

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



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

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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.

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



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..

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	E	xam	ple:	The	Telf	fer province
Dec-12 Mineral Resources	Measured Res	HERCE	and the second	ated Reves		1
Cold and Copper Resources # = includes stockpiles()	Dry Orld Torr Orld (git Au	Copper Grade (Cu)	Dry Tonnes (million)	Gedd Gedde Igh Aut	Copper Orsek (% Ca)	Not so easy here: some of the Indicated
Main Dome Open Pit #	28 0.4	3 0	380	0.65	6.08	Resource has not been
West Dome Open Pit			390	0.53	0.06	Resource has not been
feller Underground		~	78	- 14	0.32	converted to Probable
Other			0.57		0.03	Reserve – but we
OCallaghans			60		6.29	don't know how much
Dec-12 Ore Reserves	Proved Reserve		Trobable	Roserve		don t know now much
Gold and Copper Reserves # = includes stockpiles)	Dry Gold Tonnes Grade (million) (g/t Au)	Copper Grade (% Cu)	Dry Tomas (million)	Gold Grade (ph Au)	Coport Orde ('9 Cu)	
Main Dome Open Pit #	28 0.4	3 0.07	240	0.76	0.09	
Main Done Open Pit #	28 0.4	3 0.07	240	0.76	6.09	

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.

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.

	E1-F1-G1 Reserv	E1-F1-G2	E2-F2-G1	E2-F2-G2 Resources (Mt)	E2-F2-G3
Cement Quarry A (note 1)	Proved	Probable	Measured	Indicated	Inferred
Chy 1	1.43	2.94	0.00	5.46	0.0
Chy 2	0.89	1.14	0.00	3.51	0.0
Limestone 1	1.61	18.25	0.00	21.25	0.0
Limetone 3	1.18	4.26	0.00	8.23	0.0
Cement Onarry B (note 2)					
Limestone 1	2.37	0.00	0.00	0.00	0.0
Limestone 2	32.18	0.00	2.37	0.00	0.0
Cement Quarry C (note 2)					
Limestone 1	0.57	4.50	0.00	5.23	0.0
Limestone 2	24.00	0.00	0.00	1.07	0.0
Aggregate Quarry A (note 3)					
Und I	3.35	0.00	16.05	0.00	0.0
URE 2	40.90	0.00	4.19	0.00	0.0
Aggregate Quarty B (note 4)	141.00	0.00	0.03	10.00	

and descent of BRUC.	E1-F1-G1	E1-F1-G2	E2-F2-G1	E2-F2-G2	E2-F2-G3
Cement Quarry A (note 1)	Reserves Proved	(Mt) Probable	Measured	Resources (Mt) Indicated	Inferred
Clay1 Clay2 Linotone1 Linotone2 Linotone3	1.43 0.89 1.61 0.00 1.18	2.98 1.14 18.25 0.00 4.25	0.00 0.00 0.05 1.75 0.00	5.46 3.51 27.25 2.61 8.23	0.00 0.00 0.00 0.00 0.00
ote 1. Reserves and	resources a	omprise	the materi	als to	0.00
e used in the kiln fee Iclude, amongst oth	ed. Material er things, th	s in the R at tonna	esources c ge beyond	lasses the	0.00
atio necessary for th	e current re	cipe but v	which are		0.00
xpected to be worke r use of imported ad	d in the futi Iditives.	ire by add	ditional ble	ending	0.00
	of such mai	torial part	on a sift a d	co not	

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.

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	Construction Mineral	S
Other materials are currently no propose	vered based on the current kiln recipe. available at the site, but for which there is al for recovery hence are not reported.	22005 0.00 0.00 0.00 0.00
Criment Dearry 8 (note 2): Limestone 1 Limestone 2 Criment Dearry 7 (note 2): Limestone 1 Limestone 2	2.77 0.00 2.01 0.00 2.18 0.00 2.17 0.00 0.57 4.50 0.00 5.21 0.57 4.50 0.00 5.21	0.00
All resources and resources an	3.35 0.00 16.05 0.00 erves quoted can be processed is. There may be additional	0.00 0.00
material not reporte we have no number	d – but this cannot be listed as s for it	• • • • • • • •

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

In Aggregate Quarry "A",

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

These therefore qualify for the subclass 'Justified for Development', **F1.3**

	E1-F1-G1 E Reserves ()	1-F1-G2 1	2-F2-G1 E	2-F2-G2 sources (Mt)	E2-F2-G3
Cement Quarry A (note I)	Proved	Probable	Measured	Indicated	Inferred
ble for the produce the produc	ction of aggi ver the resou	regates. A irces state	dditional p d.	permits	0.0 0.0
able for the product necessary to recovered Reserves, "Just	ction of aggi ver the resou tified for dev	regates. A prces state velopment	dditional p d. :" = E1.1-F	nermits	0.0
able for the product necessary to recover red Reserves, "Just Limstore 1 Limstore 2	ction of aggi ver the resou tified for dev 2400	regates. A prces state velopment	dditional p d. :" = E1.1-F	nermits 1.3-G1	0.0 0.0 0.0 0.0 0.0
able for the product necessary to recover red Reserves, "Just Immisse 2 Agreade Quere A (note 3) Liss 1 Liss 2	ction of aggiver the resound tified for dev	velopment	dditional p d. " = E1.1-F 0.00 9.00	nermits	0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0



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**

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

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			ind dio ci i	
Deschart	Resident	S Brown	Dechelola	Tatel
Floduct	Region	2012 (kt)	2012 (kt)	2012 (kt)
Ball clawr		2012 (22)	2012 (kt)	2012 (81)
	Asia/Pacific	899		899
	Europe incl. Africa	8304	4415	12719
	North America	4687	1695	6382
	Total	13890	6110	20000
Carbonates (calcite, marble, chalk, limesto	ne, dolomite & di	mension 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
40.1			20:	- 9/

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.

	2 💸	Imerys 2 mineral	2012: iı s	ndustri	al	
	Product	Region	Proven	Probable	Total	
	Ball clays		E1-F1-G1	E1-F1-G2	2012 (kt)	
		Asia/Pacific	899		899	
		Europe incl. Africa	8304	4415	12719	
For g woul	bling these blem - all elines. overnmen d have to idual coun	t reporting it is l be asked for det try or regions w	ikely that ikely that ail relating	the comparison of the comparis	ent 000 015 02 68 110 95 02 02 02 02 02 02 02 02 02 02	

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.

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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.



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.

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.





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.

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Data from a COAL EXPLORATION project in Mongolia

This is a simple range of coal tonnages.

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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.



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.

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MALE MALENAL MALENAL	Carpenta	aria 2013: iron ore
At the Brae Dam project Consultant Target of magnetite "DTR") of and 850 n iron (Tabl	mar JV (CAP earning ct (100% CAP), indep s Pty Ltd (H&SC) hav 1.7 to 3.1 billion mass recovery (Da 12 to 27% for bett nillion tonnes of iro le 1).	in) and contiguous South endent geologists H&S e estimated an Exploration nnes, with an estimated avis Tube Recovery, ween 200 million tonnes on concentrate at 63-67%
The potent conceptual define a mi exploration resource.	ial quantity and grade in nature and there i ineral resource. It is u will result in determa	e of the Exploration Target is is insufficient exploration to uncertain if further ination of a mineral

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.....

Explo	ratior	n Targ	let	est	timat	es (d	letail):	
Target Area South Dam	Strike (km) 9.5-10.5	Thickness (m) 80-120	Dow (m)	n Dip 250	Volume (Mm3) 190-320	Density (t/m3) 3.05	In situ Tonnes (Mt) 580-960	Concentra (Mt) 70-260
Braemar W	8.5-9.5	80-120		250	170-290	3.05	520-870	60-230
Braemar C	8.0-9.0	80-120		250	160-270	3.05	490-820	60-220
Braemar E	2.0-4.5	100-150		250	50-170	3.05	150-515	20-140
Totals	28.0-33.5	80-150		250	570-1040		1740-3170	210-850
Supporting data: three revese-circulation drill holes and some geophysical exploration (airborne and ground magnetic data): Probably E3-F3.2-G4 because data are not site-specific								

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

Assignment to UNFC-2009 subclasses 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.

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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.

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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.



What we have learned

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Granularity Always quote the main class as well as any gub class. This allows expected

- any sub-class. This allows consistent aggregation of data using the main classes
- Possible to map CRIRSCO data naturally to sub-classes in many cases
 But – there is a particular problem with
- exploration data (E3-F3-G4)

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 subdivisions for Exploration Data require some re-definition. This will be discussed as a separate issue.



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.

if time allows -

Possible standardisation on a pointof-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.



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 backcalculated from Reserves.



Two sets of mineral resources can be added together

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



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.

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There are two problems with the currently defined sub-division of the E3-F3-64 class: 1. G4 sub-division in Specification P is data codification. But a range is really a single item of information: just ONE sub-class! Ranges of multiple quantity/quality parameters cannot be accommodated in sub-classes as defined 2. F3 sub-division in specification R is defined in terms of relative extents of geological knowledge rather than technical feasibility

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**.



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.

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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.



Orthogonality?

The UNFC-2009 E, F, and G axes should be orthogonal (otherwise we don't have a cube!)

If the F axis represents progress of 'studies' ('project maturity'?), surely these cannot include studies which are socio-economic (E

That would imply that we really need only

axis) or geological (G axis)?

ONE axis M = project maturity

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

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 ?

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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



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

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Now the proposed replacement definitions in specification R

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



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

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

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

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All of the CRIRSCO classes



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Recommendations for government reporting	
"Competent Person" validation	
 Competent Person requirement for most public listed companies Not normally required for unlisted and private companies EU Minventory project suggests a government Competent Person to provide consistent data validation: this is a useful general recommendation 	
~*************************************	۲

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

A brief summary of other conclusions

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

- 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 Recommendations for government reporting

 "Competent Person" validation
 >Data formats; tabulation (use two UNFC columns in database, for main classes, and for sub-classes – or use ONLY the main classes)
 >Watch for CRIRSCO resource estimates reported *inclusive* of reserves (avoid double-counting)
 > Watch for reporting from joint ventures (avoid double-counting, avoid under-counting)
 > Take care if aggregating data reported using very different economic assumptions or cutoff grades

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Recommendations for government reporting (continued) > For 'undiscovered' resources, preferable to use non-company data (e.g. geological survey) – as also for uneconomic or unrecoverable > DO NOT aggregate CRIRSCO-derived resources (E2F2G1-3) classes with reserves (E1F1G1-2) because the estimates are not comparable > Use a consistent Reference Point (for solid minerals, this is usually delivery to processing plant)

* © (; ? ::: @ A * © (; ? ::: @

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!)

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.



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.

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.





the Specifications, or avoid using E3-F3-G4 sub-classes Some detailed updates proposed for the Bridging 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.

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.

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 subclasses 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.



