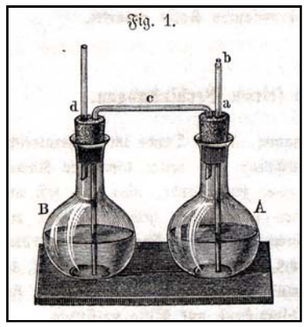

A Taxonomy of Historical Pigments

THE PIGMENTUM PROJECT

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THE NEED FOR A COMPREHENSIVE PIGMENT TAXONOMY

The principal reasons for establishing systematic listings in general are self-evident and the development of such schema has occurred in most fields of endeavour. A few of the benefits are:

- Functional classification. The organisation of the listing imparts a level of meta-information to the members of the list, implying specific relationships.
- Common language. Field-wide acceptance of such listings gives a common set of terms that can be used.
- As an *aide memoir*.

The classification of pigments too, has been addressed in the past and examination of the literature shows that there are numerous pigment lists, both ancient and modern. It was found however, that there are a number of consistent issues that cannot be readily resolved without forming a new listing. These issues include:

- Incompleteness. Typically, pigment lists are narrow in focus, dealing with certain periods or places, or groups of pigments. Examples are the books by Harley (1982) and Carlyle (2001) that review British sources from the seventeenth to the nineteenth centuries, and recent textbooks on industrial inorganic and organic pigments by Buxbaum (1998) and Herbst and Hunger (1997). These are all excellent sources in their own sphere, but tend to fail on the periphery of their remit (say, the chemistry in documentary-based reviews, the history in the chemistry-based ones). A partial exception is the *Colour Index* (e.g., 3rd edition, 1971), which in fact contains many obscure compounds and is evidently based on sources dating as far back as the late nineteenth century The intent of it though is clearly to serve the needs of the current industrial sphere, which leads to poor coverage of historical pigments.
- Overextension. Many commonly used terms in fact refer to more than one compound, so that use of them can lead to both loss of information and gross error. Study of the context in which modern pigment literature uses the term 'lead white' for example, frequently seems to equate to the lead carbonate hydroxide $2PbCO_3.Pb(OH)_2$, even when there is little confirmatory evidence that this specific compound is present. It might though, in the broadest sense, as any white compound containing lead, be applied to any one of the various carbonates and carbonate hydroxides or, as Winter (1981) and others have shown, a number of other sulfates, phosphates and compound mixtures. The related error of using the mineral name (hydrocerussite) without qualification is also not uncommon.
- False specificity. A related issue is the use of overly narrow definitions of pigment terms. A classic example is so-called 'verdigris', where this might be one of at least eight, possibly ten, compounds thought to exist (Scott, 2001). It is a surprisingly common practice however to identify the compound merely as 'verdigris ($Cu(CH_3COO)_2.3Cu(OH)_2$)'. Numerous other examples could be given.
- Lack of defined structure. Most lists are at best only semi-systematically organised, usually by a utilitarian feature such as colour or stability. For identification purposes we are more likely to be interested in the chemistry (elemental composition, crystal structure and so forth).
- Inconsistency. Although there appears to be a broad consensus in the way some terms are used, there is no field-wide standard. Moreover, the terms that are most frequently and widely used also often fail the overextension criterion.
- Poorly defined relationships. There is often a pronounced gap between terms and our ability to relate analytical findings to them. An instance of this might be certain proprietary names (e.g., 'Freeman's Lead White') that refer to particular compositions, perhaps known from documentary sources but not identified analytically because the specific relationship between the components is unknown (Corbeil *et al*, 1999).
- Use of related terms as synonyms. Frequently, words that are given as synonymous are so only in a very broad sense. In practice these often seem to be variants: pigments of basically similar constitution, but from different sources and/or prepared by different methods. In essence this means that there may be differences between them that allow distinction, perhaps by particle morphology or the presence of other components that relate to manufacturing practices. An example of this is the use of the term 'French ultramarine' to mean any synthetically prepared ultramarine; in fact it should properly be applied only to a synthetic ultramarine prepared by the Guimet process.

DEVELOPMENT OF THE PIGMENT LISTINGS

In response to these issues two core listings were developed, one relating to general and historical pigment terms and the other to identifiably distinct chemical compounds. That for general pigment terms will not be discussed here. However, both core listings were based on a wide variety of sources including critical literature surveys of historical documentary sources, secondary reviews of documentary sources, modern published sources giving analytical results from studies of historical artefacts, modern literature on commercial pigments and certain related chemical literature (primarily studies of individual compounds or compound groups giving known crystal structures, stabilities and so forth). Use was also made of various online abstracting services.

Some limits had to be necessarily placed on the scope to make the project achievable. So, while the aim was to be as comprehensive as possible in the literature examined, certain types of sources such as manuscript accounts, port records, modern patent literature and such like were not generally reviewed except in certain important cases, or via the secondary literature consulted. Constraints were also placed on terminology in languages other than English unless there was obvious transfer of terminology or an evident etymological link. Modern trade names were also largely ignored though some consideration was given to this issue, as will be discussed later.

As a first step it was necessary to address the issue of how many distinct pigments might have been used historically. A major reason for this was that, apart from the desire for comprehensiveness, we also wanted to avoid having to make many radical alterations to accommodate revisions when the need for new groupings arose in the future. Consequently we elected to cover as wide a range of sources as possible, so that not just those pigments found on Western European easel paintings are detailed (though for which there is an inevitable bias, largely because most of the research has been conducted in this area), but also those from wallpaintings, decorative paint and archaeological material, world-wide, without barrier of time or place. We have excluded compounds only used in ceramic glazes but included those applied as an unfired decoration. Dyes are also only included insofar as they have been used in a pigment context, as colour laid onto a substrate.

On a similar basis it was decided that the work should be inclusive. Where the evidence for use of a compound was only partial, it was none-the-less included; an example might be a mineral identified by X-ray diffraction, where it may actually be the synthetic analogue or an alteration product of another, more common, pigment. It also seemed appropriate to include some minerals which are rare and unlikely to have been used themselves as pigments but which are well characterised analogues of pigments (examples would be the rare mineral bayerite and the isostructural aluminium hydroxide produced synthetically, or cuprorivaite and the related calcium copper silicate commonly known as 'Egyptian blue'). Thirdly, the chemical literature was also consulted to clarify what related forms and crystalline phases of a compound existed and might reasonably be stable under pigment conditions (though we excluded related compounds not directly described as pigments that are unstable under 'normal' conditions such as high-pressure species). A number of other compounds detailed in the historical literature were also added, even though they may have been experimental – Salter's 1869 edition of Field's *Chromatography* for example gives a large number of such compounds – the rationale here being that they *might* have been used or are of possible interest both to historians and practitioners; these have also been cross-checked with the chemical literature in an effort to provide some indication of composition.

It has also been necessary in reading the literature to decide if a distinct pigment is involved or if a term refers to an established synonym, variant, or is of indefinite or variable meaning. A synonym, as in the usual meaning of the word, refers here to a term of direct equivalence, but not considered to be the primary common name. Various types of synonym might be discerned such as:

Historical synonyms - terms of historical usage, now discontinued;
Contemporary synonyms - terms of current usage or recent invention;
Linguistic synonyms - either
    Equivalent terms in different languages or
    Orthographic variants;
Commercial synonyms - specific trade names applied by manufacturers or suppliers to identical pigments.

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Variants on the other hand are pigments that have some distinct physical, or perhaps chemical, feature that alters a specific generic or composite pigment to a significant degree. Examples are shade variants and morphological variants; in the former the precise colour distinguishes this pigment from another, in the latter it is the physical shape. Importantly, we should note that shade variants have not been taken into special account in the naming conventions described above, while morphological variants have. Such considerations led us to develop a series of categories capable of reflecting some of these subtleties, particularly the appellation 'variant' and its further qualification indicative of a manufacturing process or commercial source: 'variant/manufacturing' and 'variant/source'.

Finally a number of terms were encountered which in practice refer to a multiplicity of compounds, of which 'clay' is an obvious example.

In practice it was evident that, from an analytical perspective, one could reasonably list the individual compounds that form the basis of pigments as fundamental units. This allows us, for example, when seeking to identify a particle by polarised light microscopy, initially to specify the optical properties of a single compound rather than dealing with groups of compounds or natural or artificial mixtures. These fundamental unit compounds were termed as the 'generic' class, much in the same sense that pharmaceutical compounds are called 'generic' by basic chemical composition rather than, say, a trade name. Therefore the term 'generic' is defined as meaning a specific compound that occurs as a pigment or pigment component, which, by virtue of its chemical composition, crystal structure and/or mode of formation is capable of being uniquely distinguished from another.

It was also decided to divide these generics into a number of hierarchically structured classes and sub-classes based on their chemical and molecular composition, allowing greater precision in characterisation and naming. Colour is an obviously tempting approach – all blue pigments together, and so on – but this was rejected early on for the simple reason that it does not work particularly well. Instead assignment is by chemical similarity: at the most fundamental it would seem reasonable to try to associate compounds compositionally and structurally, particularly where this might reflect, say, an underlying chromophoric relationship. In practice this has developed as a general guideline to group assignment. The listing is therefore organised by the principal element or structural base unit (e.g., most lead based compounds under 'lead' and compounds based on anthraquinones, such as alizarin and purpurin, under 'anthraquinone'), then (principally) by functional group. Cases where the compound could come within more than one group (e.g., a copper-chromium compound) were assigned according to where there seems to be a clear association (e.g., chromates within chromium oxides rather than divided among the individual elements such as lead chromate, zinc chromate and so forth).

Three further sub-categorisations are used to more precisely define the pigment, constructed as pendant qualifiers. Although this leads to a certain syntactic inelegance, the meaning is however, more precise. First, there is significant precision and convenience in mineral names in that a single name specifies both the chemical composition and the crystal structure of that substance. Consequently, to extend the specificity of inorganic terminology along similar lines, mineral names are applied here where crystal structure is an important aspect. Examples might be the copper carbonate hydroxide pigments known as 'blue verditer' and 'green verditer'; these take the analogous forms to the minerals azurite and malachite, so the compounds are referenced as 'Copper carbonate hydroxide, azurite type' and 'Copper carbonate hydroxide, malachite type'. Where the pigment may be specified unambiguously without this, the mineral-crystal qualifier is generally omitted. This strictly deviates from IUPAC naming guidelines for the reason that IUPAC only provides for crystal system clarification (e.g., 'orthorhombic type') or for inclusion of the complete space group, thus causing problems where several crystalline forms actually belonged to the same crystal system; we also felt that this latter method of space groups was too complicated, losing an immediate relationship to minerals that we wanted to emphasise. Consequently it was decided that use of the mineral names was actually more helpful.

Second, there are variants due to the manufacturing process which give rise to morphological differences. Typical examples include aqueous preparation as opposed to a process involving sublimation, so-called 'wet' and 'dry' process mercury sulfide ('vermilion') pigments. Consequently, where there are morphological variants, these are referred to either by appending the morphological form (e.g., zinc oxide, acicular type), or the generally recognised formation route ('mercury(II) sulfide, cinnabar type, wet process'). As above, where the use of this is unnecessary to achieve a precise specification, the qualifier is omitted.
Third, some additional separation was thought needed, such as where the source of the material used potentially influences the final product. Simple examples would be different materials taken as starting points for chars ('peachstone char', 'cork char' etc.) or the geological deposit of a mineral, where, quite apart from the case of the so-called 'earth' pigments, it is envisaged that this system might be extended in the future to cover situations where, for example, minerals are distinct by virtue of isotopic or trace-elemental composition (e.g., sulfur isotopes in lazurite to distinguish examples from Afghanistan to those from Lake Baikal in Siberia, or the Chilean Andes).

ARCHETYPAL PIGMENTUM PROJECT

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A: GENERIC COMPOUNDS

α	β	γ	δ	ε	GROUP	SUB-GROUP	CHEMICAL NAME	VARIANT FORM	CHEMICAL FORMULA	CAS Number	LITERATURE	Notes
1	1	1			**Aluminium**	*Aluminium*	Aluminium		Al	7429-90-5	Edwards (1927); Gettens & Stout (1966); Smith (1983a,b)	
1	2				**Aluminium**	*Carbonates*						
1	3				**Aluminium**	*Cyanides*						
1	4				**Aluminium**	*Halides*						
1	5				**Aluminium**	*Nitrates*						
1	6	1	1		**Aluminium**	*Oxides & hydroxides*	Aluminium oxide, amorphous type	Synthetic form	Al_2O_3(am)		Heaton (1928) [as aluminium oxide] then chem. lit.	
1	6	2	1		**Aluminium**	*Oxides & hydroxides*	Aluminium oxide, corundum type	Synthetic form	α-Al_2O_3	1344-28-1	Heaton (1928) [as aluminium oxide] then chem. lit.	
1	6	2	2		**Aluminium**	*Oxides & hydroxides*	Corundum	Mineral	α-Al_2O_3	1302-74-5	Heaton (1928) [as aluminium oxide] then chem. lit.	
1	6	2	2		**Aluminium**	*Oxides & hydroxides*	Aluminium hydroxide, boehmite type		γ-Al(O)OH		Synthetic analogue	
1	6	2	2		**Aluminium**	*Oxides & hydroxides*	Boehmite		γ-Al(O)OH	1318-23-6	Helwig (1995) in 'red earth' (Forbes 6.02.78); Watchman et al. (in press)	
1	6	2	2		**Aluminium**	*Oxides & hydroxides*	Aluminium hydroxide, diaspore type		α-Al(O)OH		Related compound	
1	6	2	2		**Aluminium**	*Oxides & hydroxides*	Diaspore		α-Al(O)OH	14457-84-2	Related mineral	
1	6	3	1		**Aluminium**	*Oxides & hydroxides*	Aluminium hydroxide, bayerite type	Synthetic form	α-$Al(OH)_3$	21645-51-2	Winchell (1927)	
1	6	3	2		**Aluminium**	*Oxides & hydroxides*	Bayerite	Mineral	α-$Al(OH)_3$	20257-20-9	Mineral analogue	
1	6	4	1		**Aluminium**	*Oxides & hydroxides*	Aluminium hydroxide, doyleite type	Synthetic form	$Al(OH)_3$		Related synthetic analogue	
1	6	4	2		**Aluminium**	*Oxides & hydroxides*	Doyleite	Mineral	$Al(OH)_3$		Related mineral	
1	6	5	1		**Aluminium**	*Oxides & hydroxides*	Aluminium hydroxide, gibbsite type	Synthetic form	γ-$Al(OH)_3$		Synthetic analogue	
1	6	5	2		**Aluminium**	*Oxides & hydroxides*	Gibbsite	Mineral	γ-$Al(OH)_3$	14762-49-3	Helwig (1995) in 'red earth' (Forbes 6.02.78)	
1	6	6	1		**Aluminium**	*Oxides & hydroxides*	Aluminium hydroxide, nordstrandtite type	Synthetic form	$Al(OH)_3$		Related synthetic analogue	
1	6	6	2		**Aluminium**	*Oxides & hydroxides*	Nordstrandtite	Mineral	$Al(OH)_3$	13840-05-6	Mineral analogue	
1	7	1	1		**Aluminium**	*Phosphates*	Aluminium phosphate, angelite type	Synthetic form	$Al(PO)_4$	7784-30-7	Church (1901) as aluminium phosphate, then chem. lit. e.g. Becher	
1	7	1	2		**Aluminium**	*Phosphates*	Angelite	Mineral	$Al(PO)_4$		Mineral analogue	
1	7	2	1		**Aluminium**	*Phosphates*	Aluminium phosphate		$AlH_3(PO_4)_2$	13967-89-0	Church (1901) as aluminium phosphate, then chem. lit.	
1	7	3	1		**Aluminium**	*Phosphates*	Aluminium phosphate		$Al(H_2PO_4)_3$	13530-50-2	Church (1901) as aluminium phosphate, then chem. lit.	
1	8				**Aluminium**	*Sulfides*						
1	9	1	1		**Aluminium**	*Sulfates*	Aluminium sulfate		$Al_2(SO_4)_3$	17927-65-0	*Colour Index* (1971)	
1	9	2	1		**Aluminium**	*Sulfates*	Potassium aluminium sulfate hydroxide, alunite type		$KAl_3(SO_4)_2(OH)_6$		Synthetic analogue	
1	9	2	2		**Aluminium**	*Sulfates*	Alunite		$KAl_3(SO_4)_2(OH)_6$		Newman et al. (1980)	Newman et al. give: $(K,Na)Al_3(SO_4)_2(OH)_6$
1	10	1	1		**Aluminium**	*Organo-aluminium compounds*	Aluminium stearate		$[CH_3(CH_2)_{16}COO]_3Al$		Gettens & Stout (1966)	
2	1	1	1		**Antimony**	*Antimony*	Antimony		Sb	7440-36-0	*Colour Index* (1971)	
2	2				**Antimony**	*Carbonates*						
2	3				**Antimony**	*Cyanides*						
2	4	1	1		**Antimony**	*Halides*	Antimony(III) chloride		$SbCl_3$	10025-91-9	*Colour Index* (1971)	
2	4	2	1		**Antimony**	*Halides*	Antimony chloride oxide		SbOCl	7791-08-4	*Colour Index* (1971), then chem. lit.	
2	4	3	1		**Antimony**	*Halides*	Antimony chloride oxide		$Sb_4Cl_2O_5$	12182-69-3	*Colour Index* (1971), then chem. lit.	
2	4	4	1		**Antimony**	*Halides*	Antimony chloride oxide		$Sb_8Cl_2O_{11}$	12323-75-0	*Colour Index* (1971), then chem. lit.	
2	4	4	2		**Antimony**	*Halides*	Onoratoite	Mineral	$Sb_8Cl_2O_{11}$	12381-11-2	*Colour Index* (1971), then chem. lit.	
2	5				**Antimony**	*Nitrates*						
2	6	1	1		**Antimony**	*Oxides & hydroxides*	Antimony(III) oxide, senarmontite type		Sb_2O_3		*Colour Index* (1971) as antimony oxide, then chem. lit.	
2	6	``1	2		**Antimony**	*Oxides & hydroxides*	Senarmontite	Mineral	Sb_2O_3	12412-52-1	Mineral analogue	
2	6	2	1		**Antimony**	*Oxides & hydroxides*	Antimony(III) oxide, valentinite type		Sb_2O_3	1309-64-4	*Colour Index* (1971) as antimony oxide, then chem. lit.	
2	6	2	2		**Antimony**	*Oxides & hydroxides*	Valentinite	Mineral	Sb_2O_3	1317-98-2	Mineral analogue	
2	6	3			**Antimony**	*Oxides & hydroxides*	Antimony(IV) oxide		SbO_2 (or Sb_2O_4)		Gloger & Hurley (1973)	
2	6	4			**Antimony**	*Oxides & hydroxides*	Antimony(V) oxide		Sb_2O_5		Gloger & Hurley (1973)	'…has no industrial importance as a pigment'
2	7				**Antimony**	*Phosphates*						
2	8	1			**Antimony**	*Sulfides*	Antimony(III) sulfide, amorphous type		Sb_2S_3(am)			'Antimony vermilion'
2	8	2	1		**Antimony**	*Sulfides*	Antimony(III) sulfide, stibnite type		Sb_2S_3	1345-04-6	*Colour Index* (1971)	
2	8	2	2		**Antimony**	*Sulfides*	Stibnite	Mineral	Sb_2S_3	1317-86-8	Ferretti et al. (1991)	
2	8	3			**Antimony**	*Sulfides*	Antimony(V) sulfide		Sb_2S_5	1315-04-4	*Colour Index* (1971)	'Antimony vermilion'. According to Cotton et al. (1999), Mossbauer spectroscopy shows only Sb(III) to be present
2	8	4			**Antimony**	*Sulfides*	Antimony oxide sulfide		$2Sb_2S_3.Sb_2O_3$(am) ?	12412-48-5	Heaton (1928) and chem. lit.	
					Antimony	*Sulfides*	Kermesite		Sb_2S_2O	12196-78-0	Related mineral	
2	9				**Antimony**	*Sulfates*						
2	10				**Antimony**	*Organo-antimony compounds*						
3	1				**Arsenic**	*Arsenic*						
3	2				**Arsenic**	*Carbonates*						
3	3				**Arsenic**	*Cyanides*						
3	4				**Arsenic**	*Halides*						
3	5				**Arsenic**	*Nitrates*						
3	6	1	1		**Arsenic**	*Oxides & hydroxides*	Arsenic oxide, arsenolite type		As_2O_3	12505-67-8	FitzHugh (1997)	
3	6	1	2		**Arsenic**	*Oxides & hydroxides*	Arsenolite		As_2O_3	1303-24-8	Mineral analogue	

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α	β	γ	δ	ε	GROUP	SUB-GROUP	CHEMICAL NAME	VARIANT FORM	CHEMICAL FORMULA	CAS Number	LITERATURE	Notes
3	6	2			**Arsenic**	*Oxides & hydroxides*	Claudetite I		As_4O_6	13473-03-5	Related mineral	
3	6	3			**Arsenic**	*Oxides & hydroxides*	Claudetite II		As_4O_6	13473-03-5	Related mineral	
3	7				**Arsenic**	*Phosphates*						
3	8	1	1		**Arsenic**	*Sulfides*	Arsenic sulfide, amorphous type		As_2S_3(am)	1303-33-9		
3	8	2	1		**Arsenic**	*Sulfides*	Arsenic sulfide, alacranite type		As_8S_9		Synthetic analogue	
3	8	2	2		**Arsenic**	*Sulfides*	Alacranite		As_8S_9		FitzHugh (1997)	
3	8	3	1		**Arsenic**	*Sulfides*	Arsenic sulfide, dimorphite type, α form		As_4S_3	12512-13-9	Noll (1981) & FitzHugh (1997), then min. lit.	Said to be dimorphic (α-, β- forms)
3	8	3	2		**Arsenic**	*Sulfides*	Dimorphite, α form		As_4S_3	1303-41-9	Noll (1981) & FitzHugh (1997), then min. lit.	Said to be dimorphic (α-, β- forms)
3	8	4	1		**Arsenic**	*Sulfides*	Arsenic sulfide, dimorphite type, β form		As_4S_3	12512-13-9	Noll (1981) & FitzHugh (1997), then min. lit.	Said to be dimorphic (α-, β- forms)
3	8	4	2		**Arsenic**	*Sulfides*	Dimorphite, β form		As_4S_3	1303-41-9	Noll (1981) & FitzHugh (1997), then min. lit.	Said to be dimorphic (α-, β- forms)
3	8	5	1		**Arsenic**	*Sulfides*	Arsenic sulfide, duranusite type		As_4S			
3	8	5	2		**Arsenic**	*Sulfides*	Duranusite		As_4S		Noll (1981); FitzHugh (1997)	
3	8	6	1	1	**Arsenic**	*Sulfides*	Arsenic sulfide, orpiment type	'Dry' process	As_2S_3	1303-33-9	Widely recognised	
3	8	6	1	2	**Arsenic**	*Sulfides*	Arsenic sulfide, orpiment type	'Wet' process	As_2S_3	1303-33-9	Widely recognised	
3	8	6	2		**Arsenic**	*Sulfides*	Orpiment		As_2S_3		Widely recognised	
3	8	7			**Arsenic**	*Sulfides*	Arsenic sulfide, pararealgar type		AsS			
3	8	7			**Arsenic**	*Sulfides*	Pararealgar		AsS		Green (1995); Corbeil & Helwig (1995)	
3	8	8	1		**Arsenic**	*Sulfides*	Arsenic sulfide, realgar type		As_2S_2	12279-90-2	Synthetic analogue	
3	8	8	2		**Arsenic**	*Sulfides*	Realgar		As_2S_2	12044-30-3	Widely recognised	
3	8	9	1		**Arsenic**	*Sulfides*	Arsenic sulfide, uzonite type		As_4S_5	25114-28-7	FitzHugh (1997), then chem. lit.	
3	8	9	2		**Arsenic**	*Sulfides*	Uzonite		As_4S_5		FitzHugh (1997)	
3	9				**Arsenic**	*Sulfates*						
3	10				**Arsenic**	*Organo-arsenic compounds*						
4	1				**Barium**	*Barium*						
4	2	1	1		**Barium**	*Carbonates*	Barium carbonate		$BaCO_3$	513-77-9	*Colour Index* (1971); Heaton (1928)	
4	2	1	2		**Barium**	*Carbonates*	Witherite		$BaCO_3$	14941-39-0	*Colour Index* (1971); Heaton (1928)	
4	3				**Barium**	*Cyanides*						
4	4				**Barium**	*Halides*						
4	5				**Barium**	*Nitrates*						
4	6	1			**Barium**	*Oxides & hydroxides with Group 3-11 elements (Mn)*	Barium manganese oxide		$BaMnO_4$		Widely recognised	
4	6	2			**Barium**	*Oxides & hydroxides with Group 3-11 elements (Mn)*	Barium manganese oxide		Ba_3MnO_5			Unknown validity
4	6	3			**Barium**	*Oxides & hydroxides with Group 3-11 elements (Mn)*	Barium manganese oxide		[---]			Unknown validity
4	6	4	1		**Barium**	*Oxides & hydroxides with Group 3-11 elements (Mn)*	Barium manganese oxide, hollandite type		$Ba_{0.8\text{-}1.5}[Mn(IV),Mn(III)]_8O_{16}$ {or $BaMn_8O_{16}$}		Guineau et al. (2000)	Post (1999) classifies this as a manganese oxide
4	6	4	2		**Barium**	*Oxides & hydroxides with Group 3-11 elements (Mn)*	Hollandite		$Ba_{0.8\text{-}1.5}[Mn(IV),Mn(III)]_8O_{16}$ {or $BaMn_8O_{16}$}		Guineau et al. (2000)	Post (1999) classifies this as a manganese oxide
4	6	5	1		**Barium**	*Oxides & hydroxides with Group 3-11 elements (Mn)*	Barium manganese oxide, romanechite type		$Ba_{0.66}Mn(IV)_{3.68}Mn(III)_{1.32}O_{10}{\cdot}1.34H_2O$ {or $BaMn_9O_{16}(OH)_4$}		Guineau et al. (2000)	Post (1999) classifies this as a manganese oxide
4	6	5	2		**Barium**	*Oxides & hydroxides with Group 3-11 elements (Mn)*	Romanechite		$Ba_{0.66}Mn(IV)_{3.68}Mn(III)_{1.32}O_{10}{\cdot}1.34H_2O$ {or $BaMn_9O_{16}(OH)_4$}		Guineau et al. (2000)	Post (1999) classifies this as a manganese oxide
4	7				**Barium**	*Phosphates*						
4	8				**Barium**	*Sulfides*						
4	9	1	1		**Barium**	*Sulfates*	Barium sulfate		$BaSO_4$	7727-43-7	Widely recognised	
4	9	1	2		**Barium**	*Sulfates*	Baryte		$BaSO_4$	13462-86-7	Widely recognised	
4	10				**Barium**	*Organo-barium compounds*						
5	1	1			**Bismuth**	*Bismuth*	Bismuth		Bi			'Wismutmalerei'
5	2				**Bismuth**	*Carbonates*						
5	3				**Bismuth**	*Cyanides*						
5	4	1			**Bismuth**	*Halides*	Bismuth chloride oxide		BiClO	7787-59-9	*Colour Index* (1971)	
5	5	1			**Bismuth**	*Nitrates*	Bismuth nitrate		$Bi(NO_3)_3$	10361-46-3	Merck	
5	5	2			**Bismuth**	*Nitrates*	Bismuth nitrate oxide		$BiO(NO_3)$		*Colour Index* (1971)	
5	5	3			**Bismuth**	*Nitrates*	Bismuth hydroxide nitrate oxide		$Bi_2O_2(OH)(NO_3)$	1304-85-4	*Colour Index* (1971)	
5	6				**Bismuth**	*Oxides*						
5	7				**Bismuth**	*Phosphates*						
5	8	1	1		**Bismuth**	*Sulfides*	Bismuth sulfide		Bi_2S_3			
5	8	1	2		**Bismuth**	*Sulfides*	Bismuthinite		Bi_2S_3		Seccaroni (1999); Spring (2000)	
5	9				**Bismuth**	*Sulfates*						
5	10				**Bismuth**	*Organo-bismuth compounds*						
6	1				**Cadmium**	*Cadmium*						
6	2	1			**Cadmium**	*Carbonates*	Cadmium carbonate		$CdCO_3$	513-78-0	Salter (1869) 78; Fiedler & Bayard (1986) 78	
6	2	1			**Cadmium**	*Carbonates*	Otavite		$CdCO_3$		Related mineral	
6	3				**Cadmium**	*Cyanides*						
6	4				**Cadmium**	*Halides*						
6	5				**Cadmium**	*Nitrates*						
6	6	1			**Cadmium**	*Oxides & hydroxides*	Cadmium oxide		CdO		Fiedler & Bayard (1986)	
6	6	2			**Cadmium**	*Oxides & hydroxides*	Cadmium oxide hydrate				Salter (1869) 78	
6	7	1			**Cadmium**	*Phosphates*	Cadmium phosphate				Fiedler & Bayard (1986)	

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6	8	1			**Cadmium**	*Sulfides & selenides*	Cadmium sulfide, amorphous type		CdS(am)		Fiedler & Bayard (1986)	
6	8	2	1		**Cadmium**	*Sulfides & selenides*	Cadmium sulfide, greenockite type		CdS	1306-23-6	Fiedler & Bayard (1986)	α-form
6	8	2	2		**Cadmium**	*Sulfides & selenides*	Greenockite		CdS		Mineral analogue	
6	8	3	1		**Cadmium**	*Sulfides & selenides*	Cadmium sulfide, hawleyite type		CdS	1306-23-6	Fiedler & Bayard (1986)	β-form
6	8	3	2		**Cadmium**	*Sulfides & selenides*	Hawleyite		CdS		Mineral analogue	
6	8	4			**Cadmium**	*Sulfides & selenides*	Cadmium selenide		CdSe	1306-24-7	Fiedler & Bayard (1986)	
6	8	5			**Cadmium**	*Tertiary sulfides & selenides*	Cadmium selenium sulfide		Cd(S,Se)		Fiedler & Bayard (1986)	
6	8	6			**Cadmium**	*Tertiary sulfides & selenides*	Cadmium mercury sulfide		(Cd,Hg)S		*Colour Index* (1971)	
6	8	7			**Cadmium**	*Tertiary sulfides & selenides*	Cadmium zinc sulfide		(Cd,Zn)S		*Colour Index* (1971)	
6	9				**Cadmium**	*Sulfates*						
6	10	1			**Cadmium**	*Organo-cadmium compounds*	Cadmium oxalate		CdC_2O_4	814-88-0	Fiedler & Bayard (1986) 78	
7	1				**Calcium**	*Calcium*						
7	2	1	1		**Calcium**	*Carbonates*	Calcium carbonate, aragonite type		$CaCO_3$	471-34-1	Synthetic analogue	
7	2	1	2		**Calcium**	*Carbonates*	Aragonite (as mineral)		$CaCO_3$	14791-73-2	Béarat (1997)	
7	2	1	3		**Calcium**	*Carbonates*	Aragonite (from biogenic sources)	From shell	$CaCO_3$			
7	2	2	1	1	**Calcium**	*Carbonates*	Calcium carbonate, calcite type	By conversion of calcium oxide	$CaCO_3$			
7	2	2	1	2	**Calcium**	*Carbonates*	Calcium carbonate, calcite type	By precipitation	$CaCO_3$		Widely recognized; rev.: Gettens et al. (1993)	
7	2	2	2		**Calcium**	*Carbonates*	Calcite (as mineral)		$CaCO_3$	13397-26-7	Widely recognised; rev.: Gettens et al. (1993)	
7	2	2	3	1	**Calcium**	*Carbonates*	Calcite (from biogenic sources)	Coral	$CaCO_3$		Widely recognised; rev.: Gettens et al. (1993)	
7	2	2	3	2	**Calcium**	*Carbonates*	Calcite (from biogenic sources)	From *Sepia officinalis* ('cuttlefish')	$CaCO_3$		Widely recognised; rev.: Gettens et al. (1993)	
7	2	2	3	3	**Calcium**	*Carbonates*	Calcite (from biogenic sources)	Egg shell	$CaCO_3$		Widely recognised; rev.: Gettens et al. (1993)	
7	2	2	3	4	**Calcium**	*Carbonates*	Calcite (from biogenic sources)	Oyster shell	$CaCO_3$		Widely recognised; rev.: Gettens et al. (1993)	
7	2	2	4	1	**Calcium**	*Carbonates*	Calcite (mineralised forms)	Chalk	$CaCO_3$	471-34-1	Widely recognised; rev.: Gettens et al. (1993)	
7	2	2	4	2	**Calcium**	*Carbonates*	Calcite (mineralised forms)	Limestone	$CaCO_3$	471-34-1	Widely recognised; rev.: Gettens et al. (1993)	
7	2	2	4	3	**Calcium**	*Carbonates*	Calcite (mineralised forms)	Travertine	$CaCO_3$	471-34-1	Widely recognised; rev.: Gettens et al. (1993)	
7	2	2	4	4	**Calcium**	*Carbonates*	Calcite (mineralised forms)	Marble	$CaCO_3$			
7	2	3	1		**Calcium**	*Carbonates*	Calcium carbonate, vaterite type		$CaCO_3$			
7	2	3	2		**Calcium**	*Carbonates*	Vaterite		$CaCO_3$			
7	2	4			**Calcium**	*Carbonates with Group 1 & 2 elements*	Ankerite		$Ca(Mg_{0.67}Fe_{0.33})(CO_3)_2$		Ford et al. (1994)	Another source gives $Ca(Mg_{0.75}Fe_{0.25})(CO_3)_2$
7	2	5	1		**Calcium**	*Carbonates with Group 1 & 2 elements*	Calcium magnesium carbonate, dolomite type		$CaMg(CO_3)_2$	7000-29-5	Synthetic analogue	
7	2	5	2		**Calcium**	*Carbonates with Group 1 & 2 elements*	Dolomite		$CaMg(CO_3)_2$	16389-88-1	Ford et al. (1994)	
7	2	5	2		**Calcium**	*Carbonates with Group 1 & 2 elements*	Dolomite, ferroan		$Ca(Mg,Fe^{2+})(CO_3)_2$		Segal & Porat (1997)	Considered to be a solid solution series between dolomite and ankerite
7	2	6	1		**Calcium**	*Carbonates with Group 1 & 2 elements*	Calcium magnesium carbonate, huntite type		$CaMg_3(CO_3)_4$	22450-53-9	Synthetic analogue	
7	2	6	2		**Calcium**	*Carbonates with Group 1 & 2 elements*	Huntite		$CaMg_3(CO_3)_4$	19569-21-2	Riederer (1974); Barbieri et al. (1975), Clarke (1976)	
7	3				**Calcium**	*Cyanides*						
7	4	1			**Calcium**	*Halides*	Fluorite		CaF_2		Agricola (1955); Richter et al. (2001)	e.g., in form known as 'antozonite'
7	5				**Calcium**	*Nitrates*						
7	6	1	1		**Calcium**	*Oxides & Hydroxides*	Calcium hydroxide		$Ca(OH)_2$	1305-62-0	Synthetic analogue	
7	6	1	2		**Calcium**	*Oxides & Hydroxides*	Portlandite		$Ca(OH)_2$		FitzHugh (1997)	
7	6	2	1		**Calcium**	*Oxides & Hydroxides*	Calcium oxide		CaO	1305-78-8		
7	6	2	2		**Calcium**	*Oxides & Hydroxides*	Lime		CaO	1305-78-8		
7	6	3			**Calcium**	*Tertiary oxides*	Calcium aluminium oxide		[---]		Heaton (1928)	
7	7	1			**Calcium**	*Phosphates*	Calcium phosphate		$Ca(HPO_4)$	7757-93-9	Zerr & Rubencamp (1908) 241; *Colour Index* (1971) 77298 then chem. lit.	
7	7	2			**Calcium**	*Phosphates*	Calcium phosphate		$Ca(H_2PO_4)_2$	7758-23-8	[As above]	
7	7	3			**Calcium**	*Phosphates*	Calcium phosphate		$Ca_3(H_2PO_4)_2$		[As above]	
7	7	4			**Calcium**	*Phosphates*	Calcium phosphate		$Ca_4(HPO_4)(PO_4)_2$	13767-12-9	[As above]	
					Calcium	*Phosphates*	Apatite		$Ca_5(PO_4)_3(OH,F,Cl)$			
7	7	6			**Calcium**	*Phosphates*	Chloroapatite		$Ca_5(PO_4)_3Cl$	1306-04-3		
7	7	8			**Calcium**	*Phosphates*	Fluor-apatite		$Ca_5(PO_4)_3F$	1306-05-4		
7	7	9	1		**Calcium**	*Phosphates*	Hydroxylapatite (as mineral)		$Ca_5(PO_4)_3(OH)$	1306-06-5	Mineral analogue	
7	7	9	2		**Calcium**	*Phosphates*	Hydroxylapatite (from biogenic (bone) source)	From mammalian bone	$Ca_5(PO_4)_3(OH)$		Widely recognised	
7	7	5			**Calcium**	*Phosphates*	Carbonate-hydroxylapatite[1]		$Ca_5(PO_4,CO_3)_3(OH)$			
7	8				**Calcium**	*Sulfides*						
7	9	1	1		**Calcium**	*Sulfates*	Calcium sulfate, anhydrite type		$CaSO_4$	7778-18-9	Widely recognised	
7	9	1	2		**Calcium**	*Sulfates*	Anhydrite		$CaSO_4$	14798-04-0	Mineral analogue	
7	9	2	1		**Calcium**	*Sulfates*	Calcium sulfate, bassanite type[2]		$CaSO_4.½H_2O$	26499-65-0	Widely recognised	
7	9	2	2		**Calcium**	*Sulfates*	Bassanite		$CaSO_4.½H_2O$	17033-35-1	Capitán-Vallvey et al. (1994)	
7	9	3	1		**Calcium**	*Sulfates*	Calcium sulfate, gypsum type		$CaSO_4.2H_2O$	10101-41-4	Widely recognised	
7	9	3	2		**Calcium**	*Sulfates*	Gypsum		$CaSO_4.2H_2O$	13397-24-5	Mineral analogue	
7	10	1	1		**Calcium**	*Organo-calcium compounds*	Calcium acetate		$(CH_3COO)_2Ca$	62-54-4	Eikema Hommes (2002)	

[1] Also known as dahllite (formula sometimes given as $Ca_{10}(PO_4)_6(CO_3).H_2O$).
[2] Also known as the 'hemihydrate' form, bassanite being used here for consistency. However, current literature on the composition and structure of hydrates of calcium sulfate suggests that bassanite may actually have a slightly different hydration state to the synthetic analogue (0.67 *vs.* 0.5).

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7	10	2	1		**Calcium**	*Organo-calcium compounds*	Calcium oxalate, weddellite type		$CaC_2O_4.(2+x)H_2O$	563-72-4	Synthetic analogue	
7	10	2	2		**Calcium**	*Organo-calcium compounds*	Weddellite		$CaC_2O_4.(2+x)H_2O$	7236-42-2	Alessandrini et al. (1994); Russ et al. (1999)	
7	10	3	1		**Calcium**	*Organo-calcium compounds*	Calcium oxalate, whewellite type		$CaC_2O_4.H_2O$		Synthetic analogue	
7	10	3	2		**Calcium**	*Organo-calcium compounds*	Whewellite		$CaC_2O_4.H_2O$	14488-96-1	Russ et al. (1999)	
	1				**Cerium and Samarium**	*Cerium*						
	2				**Cerium and Samarium**	*Carbonates*						
	3				**Cerium and Samarium**	*Cyanides*						
	4				**Cerium and Samarium**	*Halides*						
	5				**Cerium and Samarium**	*Nitrates*						
	6				**Cerium and Samarium**	*Oxides and hydroxides*						
	7				**Cerium and Samarium**	*Phosphates*						
	8	1			**Cerium and Samarium**	*Sulfides*	Cerium sulfide					
	8	2			**Cerium and Samarium**	*Sulfides*	Cerium fluoride sulfide					
	8	3			**Cerium and Samarium**	*Sulfides*	Cerium Samarium sulfide					
	9				**Cerium and Samarium**	*Sulfates*						
	10				**Cerium and Samarium**	*Organo-cerium compounds*						
8	1				**Chromium**	*Chromium*						
8	2				**Chromium**	*Carbonates*						
8	3				**Chromium**	*Cyanides*						
8	4	1			**Chromium**	*Halides*	Chromium(III) chloride		$CrCl_3$	10025-73-7	Wohler (cf. *Colour Index* (1971) 77295), then chem. lit.	
8	4	2			**Chromium**	*Halides*	Chromium(III) chloride hexahydrate		$Cl_3CrH_{12}O_6$, probably as $[Cr(OH_2)_6]Cl_3$	10060-12-5 13820-88-7	Wohler (cf. *Colour Index* (1971) 77295), then chem. lit.	
8	5				**Chromium**	*Nitrates*						
8	6	1	1		**Chromium**	*Oxides & hydroxides*	Chromium oxide		Cr_2O_3	1308-38-9	Widely recognised (rev.: Newman (1997))	CI 77288/Pigment Green 17
8	6	1	2		**Chromium**	*Oxides & hydroxides*	Eskolaite		Cr_2O_3		Mineral analogue	
8	6	2			**Chromium**	*Oxides & hydroxides*	Chromium oxide hydrate		$Cr_2O_3.xH_2O$, where $x \sim 2$	12001-99-9	Widely recognised (rev.: Newman (1997))	
8	6	3			**Chromium**	*Oxides & hydroxides*	Chromium oxide hydrate		$Cr(OH)_3.3H_2O$ or $Cr_2O_3.9H_2O$	1308-14-1	Chem. lit.	Dihydrate?
8	6	4			**Chromium**	*Oxides & hydroxides*	Chromium oxide hydroxide		$Cr_2O(OH)_4$		*Colour Index* (1971) 77289 (unconfirmed)	
8	6	5			**Chromium**	*Oxides & hydroxides*	Chromium oxide hydroxide		$Cr_4O_5(OH)_4$		*Colour Index* (1971) 77289 (unconfirmed)	
8	6	6			**Chromium**	*Oxides & hydroxides*	Chromium oxide hydroxide		$Cr_4O(OH)_{10}$		*Colour Index* (1971) 77289 (unconfirmed)	
8	6	7			**Chromium**	*Tertiary & quaternary oxides (Al + Co, Sn; Cu, Fe)*	Chromium aluminium oxide		[---]		*Colour Index* (1971) 77288 (unconfirmed)	
8	6	8			**Chromium**	*Tertiary & quaternary oxides (Al + Co, Sn; Cu, Fe)*	Chromium aluminium cobalt oxide		[---]		Kühn (1969); Pamer (1978)	
8	6	9			**Chromium**	*Tertiary & quaternary oxides (Al + Co, Sn; Cu, Fe)*	Chromium aluminium tin oxide		[---]			
8	6	10			**Chromium**	*Tertiary & quaternary oxides (Al + Co, Sn; Cu, Fe)*	Chromium borate		[---]		*Colour Index* (1971) 77292; Newman (1997) 279	
8	6	11			**Chromium**	*Tertiary & quaternary oxides (Al + Co, Sn; Cu, Fe)*	Chromium(III) iron(III) oxide		$(Fe,Cr)_2O_3$		*Colour Index* (1971) 77500	
8	6	12			**Chromium**	*Tertiary & quaternary oxides (Al + Co, Sn; Cu, Fe)*	Chromium(III) iron(II) oxide		Cr_2FeO_4	12068-77-8	*Colour Index* (1971) 77500 then chem. lit.	
8	6	13			**Chromium**	*Tertiary & quaternary oxides (Al + Co, Sn; Cu, Fe)*	Chromoferrite		Cr_2FeO_4	1308-31-2	*Colour Index* (1971) 77500 then chem. lit. (mineral analogue)	
8	6	14			**Chromium**	*Chromates with group 1/2 elements*	Barium chromate(IV)		CrO_4Ba	10294-40-3	*Colour Index* (1971) 77103	
8	6	15			**Chromium**	*Chromates with group 1/2 elements*	Barium potassium chromate		$K_2Ba(CrO_4)_2$		*Colour Index* (1971) 77106	
8	6	16			**Chromium**	*Chromates with group 1/2 elements*	Calcium chromite		$Ca(CrO_4)_2$			
8	6	17			**Chromium**	*Chromates with group 1/2 elements*	Calcium chromate(IV)		CrO_4Ca	13765-19-0		
8	6	18			**Chromium**	*Chromates with group 1/2 elements*	Calcium chromate(IV) dihydrate		$CrO_4Ca.2H_2O$	10060-08-9	Salter (1869) as 'Gelbin's yellow' and *Colour Index* (1971) 77223	
8	6	19			**Chromium**	*Chromates with group 1/2 elements*	Calcium chromate(IV) hydroxide dihydrate		$Ca_2(OH)_2CrO_4.2H_2O$		Salter (1869) as 'Gelbin's yellow' and *Colour Index* (1971) 77223	
8	6	20			**Chromium**	*Chromates with group 1/2 elements*	Strontium chromate(IV)		CrO_4Sr	7789-06-2	*Colour Index* (1971) 77839	
8	6	21			**Chromium**	*Chromates with group 3-11 elements*	Copper chromate(VI)		$CuCrO_4$		Martel (1859) and others, then chem. lit.	

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8	6	22			**Chromium**	*Chromates with group 3-11 elements*	Copper chromate hydroxide		$CuCrO_4.Cu(OH)_2$		Martel (1859) and others, then chem. lit.	
8	6	23			**Chromium**	*Chromates with group 3-11 elements*	Copper chromate hydroxide		$CuCrO_4.2Cu(OH)_2$		Martel (1859) and others, then chem. lit.	
8	6	24			**Chromium**	*Chromates with group 3-11 elements*	Copper chromate hydroxide		$2CuCrO_4.3Cu(OH)_2$		Martel (1859) and others, then chem. lit.	
8	6	25			**Chromium**	*Chromates with group 3-11 elements*	Copper chromate(III)		$CuCr_2O_4$	12018-10-9	Martel (1859) and others, then chem. lit.	
8	6	26			**Chromium**	*Chromates with group 3-11 elements*	Copper chromate oxide hydrate		[---]		Martel (1859) and others, then chem. lit.	
8	6	27			**Chromium**	*Chromates with group 3-11 elements*	Cobalt chromate		[---]		Jännicke (1893) 70	
8	6	28			**Chromium**	*Chromates with group 3-11 elements*	Iron dichromate		$Fe_2(Cr_2O_7)_3$	10294-53-8	*Colour Index* (1971) 77505	
8	6	29			**Chromium**	*Chromates with group 3-11 elements*	Iron chromate hydroxide		$Fe(OH)CrO_4$		*Colour Index* (1971) 77505	
8	6	30			**Chromium**	*Chromates with group 3-11 elements*	Manganese chromate hydrate		CI: '$2MnO.CrO_3.2H_2O$'		*Colour Index* (1971)	
8	6	31			**Chromium**	*Chromates with group 3-11 elements*	Silver chromate		Ag_2CrO_4	7784-01-2	Salter (1869) 176 and others	
8	6	32			**Chromium**	*Chromates with group 3-11 elements*	Thallium chromate		[---]		Salter (1869) 177	
8	6	33			**Chromium**	*Chromates with group 3-11 elements*	Titanium chromate				Seccarroni (Pers. Comm.)	
8	6	34			**Chromium**	*Chromates with group 12 elements*	Cadmium chromate		$CdCrO_4$	14312-00-6	Salter (1869); Bersch (1901); *Colour Index* (1971); Fiedler & Bayard (1986)	
8	6	35			**Chromium**	*Chromates with group 12 elements*	Cadmium chromate hydroxide		$CdCrO_4{\cdot}Cd(OH)_2$		*Colour Index* (1971) 77188; Fiedler & Bayard (1986)	
8	6	36			**Chromium**	*Chromates with group 12 elements*	Mercury chromate		$HgCrO_4$ (?)	13444-75-2	Field (1835); Riffault et al. (1871)	
8	6	37			**Chromium**	*Chromates with group 12 elements*	Zinc dichromate hydrate		$ZnCr_2O_7.3H_2O$		*Colour Index* (1971) 77957	
8	6	38			**Chromium**	*Chromates with group 12 elements*	Zinc chromate(VI) hydroxide		$ZnCrO_4.4Zn(OH)_2$		*Colour Index* (1971) 77956; Lalor (1973)	
8	6	39			**Chromium**	*Chromates with group 12 elements*	Zinc sodium chromate		$Na_2O{\cdot}4ZnCrO_4{\cdot}3H_2O$		Kirk-Othmer (\$\$\$)	
8	6	40			**Chromium**	*Chromates with group 12 elements*	Zinc potassium chromate		A: ~$K_2O.4ZnCrO_4.3H_2O$ or B: $K_2CrO_4.3ZnCrO_4.Zn(OH)_2.2H_2O$		A: *Colour Index* (1971) 77955; B: Lalor (1973)	
8	6	41			**Chromium**	*Chromates with group 14-15 elements*	Lead chromate(VI)		CrO_4Pb	7758-97-6	Widely recognised (e.g., Dunn (1973))	
8	6	42			**Chromium**	*Chromates with group 14-15 elements*	Crocoite		CrO_4Pb	14654-05-8	Mineral analogue	
8	6	43			**Chromium**	*Chromates with group 14-15 elements*	Lead dichromate		$PbCr_2O_7$	13453-93-5	*Colour Index* (1971) 77607	
8	6	44			**Chromium**	*Chromates with group 14-15 elements*	Lead chromate(VI) hydroxide		$PbCrO_4.Pb(OH)_2$	12017-86-6		
8	6	45			**Chromium**	*Chromates with group 14-15 elements*	Lead chromate(VI) oxide		$PbCrO_4.PbO$	18454-12-1	Dunn (1973)	
8	6	46			**Chromium**	*Chromates with group 14-15 elements*	Lead chromate(VI) oxide		$PbCrO_4.4PbO$		Dunn (1973)	
8	6	47			**Chromium**	*Chromates with group 14-15 elements*	Lead chromate(VI) oxide hydrate		$2PbCrO_4.5PbO.H_2O$		Dunn (1973)	
8	6	48			**Chromium**	*Chromates with group 14-15 elements*	Lead chromate(VI) sulfate, monoclinic type		[---]			
8	6	49			**Chromium**	*Chromates with group 14-15 elements*	Lead chromate(VI) sulfate, orthorhombic type		[---]			
8	6	50			**Chromium**	*Chromates with group 14-15 elements*	Antimony chromate				Seccarroni (Pers. Comm.)	
8	6	51			**Chromium**	*Chromates with group 14-15 elements*	Bismuth chromate(VI)		[---]		Salter (1869)	
8	6	52			**Chromium**	*Chromates with group 14-15 elements*	Bismuth chromate(VI) oxide		$Bi_2(CrO_4)_2O$		*Colour Index* (1971) 77166	
8	6	53			**Chromium**	*Chromates with group 14-15 elements*	Tin(IV) chromate		$Sn(CrO_4)_2$	38455-77-5	Related to 'tin chromate, basic'	
8	6	54			**Chromium**	*Chromates with group 14-15 elements*	'Tin chromate, basic'		[---]		Riffault et al. (1874); Salter (1869) ?	
8	7	1			**Chromium**	*Phosphates*	Chromium phosphate hydrate		$CrPO_4.xH_2O$		*Colour Index* (1971) 77298; Newman (1997)	
8	7	2			**Chromium**	*Phosphates*	'Chromium phosphate, basic hydrated'		[---]		Church (1901); Coffignier (1924)	
8	8				**Chromium**	*Sulfides*						
8	9	1			**Chromium**	*Sulfates*	Chromium sulfate		$Cr_2(SO_4)_3$	10101-53-8	*Colour Index* (1971) 77305	
8	9	2			**Chromium**	*Sulfates*	Chromium sulfate hydrate		$Cr_2(SO_4)_3.15H_2O$		*Colour Index* (1971) 77305	
8	9	3			**Chromium**	*Sulfates*	Chromium sulfate hydrate		$Cr_2(SO_4)_3.18H_2O$		*Colour Index* (1971) 77305	
8	10				**Chromium**	*Organo-chromium compounds*						
9	1				**Cobalt**	*Cobalt*						

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α	β	γ	δ	ε	GROUP	SUB-GROUP	CHEMICAL NAME	VARIANT FORM	CHEMICAL FORMULA	CAS Number	LITERATURE	Notes
9	2	1			**Cobalt**	*Carbonates*	Cobalt carbonate		$CoCO_3$	513-79-1	*Colour Index* (1971) 77353	
9	3				**Cobalt**	*Cyanides*						
9	4				**Cobalt**	*Halides*						
9	5	1			**Cobalt**	*Nitrates*	Cobalt (II) nitrate (hexahydrate)		$Co(NO_3)_2.6H_2O$	10026-22-9	Salter (1869)	
9	5	2			**Cobalt**	*Nitrates*	Tripotassium hexanitrocobalt(III)		$K_3Co(NO_2)_6.nH_2O$		Cornman (1986); Gates (1995)	
9	5	3			**Cobalt**	*Nitrates*	Dipotassium monosodium hexanitrocobalt(III)		$K_2NaCo(NO_2)_6.nH_2O$		Cornman (1986); Gates (1995)	
9	6	1			**Cobalt**	*Oxides & hydroxides*	Cobalt(II) oxide		CoO	1307-96-9	Heaton (1928), then chem. lit.	
9	6	2			**Cobalt**	*Oxides & hydroxides*	Cobalt(III) oxide		Co_2O_3	1308-04-9	Heaton (1928), then chem. lit.	
9	6	3			**Cobalt**	*Oxides with group 2 elements (Mg)*	Cobalt magnesium oxide		[---]		Salter (1869); Riffault et al. (1874); Church (1901)	
9	6	4			**Cobalt**	*Oxides with group 3-11 elements (Cr, Fe)*	Cobalt iron oxide		[---]		Field (1835)?	
9	6	5			**Cobalt**	*Oxides with group 12 elements (Zn)*	Cobalt zinc oxide		[---]		Field (1835)?	
9	6	6			**Cobalt**	*Oxides with group 13-15 elements (B, Al, Sn, As)*	Cobalt aluminium oxide (‘cobalt aluminate’)		$CoAl_2O_4$	1345-16-0	Widely recognized. Rev.: Roy (*forth.*)	
9	6	7			**Cobalt**	*Oxides with group 13-15 elements (B, Al, Sn, As)*	Cobalt boron oxide (‘cobalt borate’)		[---]		Carlyle (2001)	
9	6	8			**Cobalt**	*Oxides with group 13-15 elements (B, Al, Sn, As)*	Cobalt tin oxide (‘cobalt stannate’)		$CoSnO_3$	1345-19-3	Widely recognized	
9	6	9			**Cobalt**	*Oxides with group 13-15 elements (B, Al, Sn, As)*	Cobalt arsenic oxide (‘cobalt arsenate’)		[---]		$$$	
9	6	10			**Cobalt**	*Oxides with group 13-15 elements (B, Al, Sn, As)*	Cobalt arsenic oxide hydrate (‘cobalt arsenate hydrate’)		[---]		$$$	
9	6	11			**Cobalt**	*Oxides with group 13-15 elements (B, Al, Sn, As)*	Erythrite		$Co_3(AsO_4)_2·8H_2O$		Related mineral	
9	6	12			**Cobalt**	*Oxides with group 13-15 elements (B, Al, Sn, As)*	Cobalt ammonium arsenic oxide		[---]		$$$	
9	7	1			**Cobalt**	*Phosphates*	Cobalt phosphate		$Co_3(PO_4)_2$	13455-36-2	*Colour Index* (1971) 77360	
9	7	2			**Cobalt**	*Phosphates*	Cobalt phosphate tetrahydrate		$Co_3(PO_4)_3.4H_2O$	36550-56-8	*Colour Index* (1971) 77360	
9	7	3			**Cobalt**	*Phosphates*	Cobalt phosphate octahydrate		$Co_3(PO_4)_2.8H_2O$	10294-50-5	*Colour Index* (1971) 77360	
9	7	4			**Cobalt**	*Phosphates*	Cobalt aluminium phosphate		[---]		Church (1901)?	
9	7	5			**Cobalt**	*Phosphates*	Cobalt ammonium phosphate hydrate		$CoNH_4PO_4.H_2O$		*Colour Index* (1971) 77362	
9	7	6			**Cobalt**	*Phosphates*	Cobalt magnesium phosphate		[---]		Heaton (1928)	
9	7	7			**Cobalt**	*Phosphates*	Cobalt zinc phosphate		[---]		Bersch (1901); Gentele (1906); *Colour Index* (1971) 77339	
9	8				**Cobalt**	*Sulfides*						
9	9				**Cobalt**	*Sulfates*						
9	10	1			**Cobalt**	*Organo-cobalt compounds*	Cobalt(II) acetate		$Co(OAc)_2$	71-48-7	Bouvier (1827) 46	As reported composition of Thénard’s blue (probably erroneous)
10	1	1			**Copper**	*Copper*						
10	1	2			**Copper**	*Copper*	Copper-nickel alloys (‘cupro-nickel’)		[Cu,Ni]		Bieganska et al (1988) as metal flake pigment	
10	1	3			**Copper**	*Copper*	Copper-zinc alloys (‘brass’)		[Cu,Zn]		Duncan et al. (1990)	
10	2	1	1		**Copper**	*Carbonates*	Copper carbonate hydroxide, azurite type		$2CuCO_3.Cu(OH)_2$		Widely recognized; rev.: Gettens & FitzHugh (1993)	
10	2	1	2		**Copper**	*Carbonates*	Azurite		$2CuCO_3.Cu(OH)_2$		Widely recognized; rev.: Gettens & FitzHugh (1993)	
10	2	2	1		**Copper**	*Carbonates*	Copper carbonate hydroxide, malachite type		$2CuCO_3.Cu(OH)_2$		Widely recognized; rev.: Gettens & FitzHugh (1993)	
10	2	2	2		**Copper**	*Carbonates*	Malachite		$2CuCO_3.Cu(OH)_2$	12069-69-1	Widely recognized; rev.: Gettens & FitzHugh (1993)	
10	2	3			**Copper**	*Carbonates*	Georgeite		$CuCO_3.Cu(OH)_2$		Related mineral [unstable]	
10	2	4			**Copper**	*Secondary substituted carbonates (Na, Zn)*	Aurichalcite		$(Cu,Zn)_5(CO_3)_2(OH)_6$		Related mineral	
10	2	5			**Copper**	*Secondary substituted carbonates (Na, Zn)*	Claraite		$(Cu,Zn)_3(CO_3)(OH)_4.4H_2O$		Related mineral	
10	2	6	1		**Copper**	*Secondary substituted carbonates (Na, Zn)*	Copper sodium carbonate, chalconatronite type		$Na_2Cu(CO_3)_2.3H_2O$		Scott (2001)	
10	2	6	2		**Copper**	*Secondary substituted carbonates (Na, Zn)*	Chalconatronite		$Na_2Cu(CO_3)_2.3H_2O$		Banik (1989); Magaloni (1996)	
10	2	7	1		**Copper**	*Secondary substituted carbonates (Na, Zn)*	Copper zinc carbonate, rosasite type		$(Cu,Zn)_2CO_3(OH)_2$		Synthetic analogue. Dunkerton & Roy (1996)	
10	2	7	2		**Copper**	*Secondary substituted carbonates (Na, Zn)*	Rosasite		$(Cu,Zn)_2CO_3(OH)_2$		Dunkerton & Roy (1996)	
10	3	1			**Copper**	*Halides*	Nantokite		CuCl	7758-89-6	Related mineral	
10	3	2	1		**Copper**	*Halides*	Copper chloride hydroxide, atacamite type		$Cu_2Cl(OH)_3$		Delbourgo (1980) and others	
10	3	3	2		**Copper**	*Halides*	Atacamite		$Cu_2Cl(OH)_3$		Synthetic analogue	
10	3	4	1		**Copper**	*Halides*	Copper chloride hydroxide, bottalackite type		$Cu_2Cl(OH)_3$		Wainwright et al (1993) and others	
10	3	4	2		**Copper**	*Halides*	Bottalackite		$Cu_2Cl(OH)_3$		Synthetic analogue	
10	3	5	1		**Copper**	*Halides*	Copper chloride hydroxide, clinoatacamite type		$Cu_2Cl(OH)_3$		Scott (2001)	
10	3	5	2		**Copper**	*Halides*	Clinoatacamite		$Cu_2Cl(OH)_3$		Synthetic analogue	
10	3	6	1		**Copper**	*Halides*	Copper chloride hydroxide, paratacamite type		$Cu_2Cl(OH)_3$		Delbourgo (1980) and others	
10	3	6	2		**Copper**	*Halides*	Paratacamite		$Cu_2Cl(OH)_3$		Synthetic analogue	

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10	3	7			**Copper**	*Halides*	Calumetite		$Cu(OH,Cl)_2.2H_2O$		Van'T Hul-Ehrnreich & Hallebeek (1972); Naumova & Pisareva (1994); Most & Hückel (1996)	
10	3	7			**Copper**	*Halides*	Anthonyite		$Cu(OH,Cl)_2.2H_2O$		Related mineral	
10	3	8			**Copper**	*Halides*	Copper chloride hydroxide hydrate		$Cu_7Cl_4(OH)_{10}.H_2O$		Wainwright et al. (1997)	Tentative identification
10	3	9	1		**Copper**	*Halides*	Copper potassium chloride		$K_2CuCl_4{\cdot}2H_2O$ (?)		Riederer (1982)	
10	3	9	2		**Copper**	*Halides*	Mitscherlichite		$K_2CuCl_4{\cdot}2H_2O$		Riederer (1982) then min. lit.	
10	3	10			**Copper**	*Halides*	Calcium copper chloride		[---]		Bersch (1901) 248 as *Kuhlmann's green*	
10	3	11			**Copper**	*Halides*	Boleite		$KAg_9Cu_{24}Pb_{26}Cl_{62}(OH)_{48}$		[Related mineral to Cumengite]	
10	3	12			**Copper**	*Halides*	Cumengite		$Pb_{21}Cu_{20}Cl_{42}(OH)_{40}$		Prasartset (1990)	
10	4	1			**Copper**	*Cyanides (excluding hexacyanoferrate(II))*	Copper(I) cyanide		CuCN	544-92-3	[References to 'copper cyanide' may be to the hexacyanoferrate]	
10	4	2			**Copper**	*Cyanides (excluding hexacyanoferrate(II))*	Copper(II) cyanide		$Cu(CN)_2$	14763-77-0	[References to 'copper cyanide' may be to the hexacyanoferrate]	
10	5	1			**Copper**	*Nitrates & nitrites*	Copper nitrate		$Cu(NO_3)_2$	3251-23-8	Eikema Hommes (2002) and chem. lit.?	
10	5	2			**Copper**	*Nitrates & nitrites*	Copper nitrate hexahydrate		$Cu(NO_3)_2.6H_2O$		Eikema Hommes (2002) and chem. lit.?	
10	5	3	1		**Copper**	*Nitrates & nitrites*	Copper nitrite hydroxide		$Cu_2(NO_3)(OH)_3$	10031-43-3	Synthetic analogue to gerhardite	
10	5	3	2		**Copper**	*Nitrates & nitrites*	Gerhardite		$Cu_2(NO_3)(OH)_3$		Van'T Hul-Ehrnreich & Hallebeek (1972); Banik (1989)	
10	6	1	1		**Copper**	*Oxides and hydroxides*	Copper(I) oxide		Cu_2O	1317-39-1	Related synthetic analogue	
10	6	1	2		**Copper**	*Oxides and hydroxides*	Cuprite		Cu_2O	1308-76-5	As associated mineral or alteration product in azurite & malachite	
10	6	2	1		**Copper**	*Oxides and hydroxides*	Copper(II) oxide		CuO	1317-38-0	Related synthetic analogue	
10	6	2	2		**Copper**	*Oxides and hydroxides*	Tenorite		CuO		As alteration product of azurite (Gutscher et al. (1989))	
10	6	3	1		**Copper**	*Oxides and hydroxides*	Copper hydroxide		$Cu(OH)_2$	20427-59-2	Related synthetic analogue [unstable as pigment?]	
10	6	3	2		**Copper**	*Oxides and hydroxides*	Spertiniite		$Cu(OH)_2$		Related mineral [unstable as pigment?]	
10	6	4			**Copper**	*Oxides with group 3-11 elements (Cr, Fe)*	Copper chromium oxide		$CuCr_2O_4$		Buxbaum (1998) 101	
10	6	5			**Copper**	*Oxides with group 3-11 elements (Cr, Fe)*	Copper chromium manganese oxide		$Cu(Cr,Mn)_2O_4$	68186-91-4	*Colour Index* (1971) 77428	
10	6	6			**Copper**	*Oxides with group 3-11 elements (Cr, Fe)*	Copper chromium iron oxide		$Cu(Cr,Fe)_2O_4$	55353-02-1	*Colour Index* (1971) 77429	
10	6	7			**Copper**	*Tertiary oxides*	Copper borate		$Cu(BO_3)_2$		Salter (1869) 285-6; *Colour Index* (1971) 77415	
10	6	8			**Copper**	*Tertiary oxides*	Copper borate hydrate				Related compound	
10	6	9			**Copper**	*Tertiary oxides*	Copper(II) tin oxide		$CuSnO_3{\cdot}nH_2O$		Elsner (1860); Salter (1869); Riffault et al. (1874); *Colour Index* (1971) 77441	
10	6	10			**Copper**	*Arsenic-containing compounds*	Copper diarsenite		$2CuO.As_2O_3.2H_2O$		Schweizer & Mühlethaler (1968); Fiedler & Bayard (1997)	
10	6	11			**Copper**	*Arsenic-containing compounds*	Copper orthoarsenite		$3CuO.As_2O_3.2H_2O$	10103-61-4	Schweizer & Mühlethaler (1968); Fiedler & Bayard (1997)	
10	6	12			**Copper**	*Arsenic-containing compounds*	Copper metaarsenite		$CuO.As_2O_3$		Schweizer & Mühlethaler (1968); Fiedler & Bayard (1997)	
10	6	13			**Copper**	*Arsenic-containing compounds*	Trippkeite		$CuAs_2O_4$		Schweizer & Mühlethaler (1968); Fiedler & Bayard (1997)	
10	6	14			**Copper**	*Arsenic-containing compounds*	Tyrolite		$Ca_2Cu_9(AsO_4)_4(OH)_{10}.10H_2O$		Stodulski et al. (1984)	
10	6	15			**Copper**	*Arsenic-containing compounds*	Copper formate arsenite		$Cu_4(OFo)_2(AsO_2)_6$?		Pey (1987)	
10	6	16			**Copper**	*Arsenic-containing compounds*	Copper acetate arsenite		$Cu_4(OAc)_2(AsO_2)_6$	12002-03-8	Widely recognized; rev.: Fiedler and Bayard (1997)	
10	7	1	2		**Copper**	*Phosphates*	Libethenite		$Cu_2(PO_4)(OH)$		Bouherour et al. (2001)	
10	7	2	1		**Copper**	*Phosphates*	Copper phosphate hydroxide, pseudomalachite type		$Cu_5(PO_4)_2(OH)_4$	62683-60-7	Synthetic analogue	
10	7	2	2		**Copper**	*Phosphates*	Pseudomalachite		$Cu_5(PO_4)_2(OH)_4$	61159-32-8	Naumova et al. (1990)	
10	7	3			**Copper**	*Phosphates*	Sampleite		$NaCaCu_5(PO_4)_4Cl.5H_2O$		Related mineral	
10	8	1			**Copper**	*Sulfides*	Copper(I) sulfide		Cu_2S	22205-45-4	Duang et al (1987), then chem. lit. (Chakrabarti & Laughlin (1983)); also perhaps Bersh (1901) as 'oil blue'	NB: copper-sulfur system is very complex!
10	8	2	1		**Copper**	*Sulfides*	Copper(II) sulfide, covellite type		CuS	1317-40-4	Duang et al (1987), then chem. lit. (Chakrabarti & Laughlin (1983)); also perhaps Bersh (1901) as 'oil blue'	
10	8	2	2		**Copper**	*Sulfides*	Covellite		CuS	1317-40-4	Duang et al (1987), then chem. lit. (Chakrabarti & Laughlin (1983)); also perhaps Bersh (1901) as 'oil blue'	
10	9	1	1		**Copper**	*Sulfates*	Copper sulfate hydroxide, antlerite type		$Cu_3SO_4(OH)_4$		Van'T Hul-Ehrnreich & Hallebeek (1972); Purinton & Newman (1985)	
10	9	1	2		**Copper**	*Sulfates*	Antlerite		$Cu_3SO_4(OH)_4$		Van'T Hul-Ehrnreich & Hallebeek (1972); Purinton & Newman (1985)	
10	9	2	1		**Copper**	*Sulfates*	Copper sulfate hydroxide, brochantite type		$Cu_4SO_4(OH)_6$		Martin and Eveno (1992)	
10	9	2	2		**Copper**	*Sulfates*	Brochantite		$Cu_4SO_4(OH)_6$		Martin and Eveno (1992)	
10	9	3			**Copper**	*Sulfates*	Bonattite		$CuSO_4.3H_2O$		Related mineral (apparently unknown as pigment)	
10	9	4			**Copper**	*Sulfates*	Chalcanthite		$CuSO_4.5H_2O$	7758-99-8	Related mineral (apparently unknown as pigment)	
10	9	5			**Copper**	*Sulfates*	Langite		$Cu_4(SO_4)(OH)_6.2H_2O$		Banik (1989); Naumova et al (1990)	
10	9	6			**Copper**	*Sulfates*	Posnjakite		$Cu_4SO_4(OH)_6.H_2O$		Naumova et al (1990); Martin et al (1995)	
10	9	7			**Copper**	*Sulfates*	Copper hydroxide sulfate hydrate		$CuSO_4.3Cu(OH)_2.½H_2O$			
10	9	8			**Copper**	*Sulfates*	Copper calcium sulfate		$3CuSO_4{\cdot}2CaSO_4$		Pigmente (1960) 236-242 as 'Mineral blau'	

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10	10	1			**Copper**	*Organo-copper compounds: Formates*	Copper(I) formate (Compound A)		Cu(HCOO)		Scott (2001)	
10	10	2			**Copper**	*Organo-copper compounds: Formates*	Copper(II) formate (Compound B)		$Cu(HCOO)_2$		Scott (2001)	
10	10	3			**Copper**	*Organo-copper compounds: Formates*	Copper(II) formate hydrate (Compound C)		$Cu(HCOO)_2.2H_2O$		Scott (2001)	
10	10	4			**Copper**	*Organo-copper compounds: Formates*	Copper(II) formate hydroxide (Compound D)		Cu(HCOO)OH		Scott (2001)	
10	10	5			**Copper**	*Organo-copper compounds: Formates*	Copper(II) formate hydroxide hydrate (Compound E)		$2Cu(HCOO)_2.Cu(OH)_2.2H_2O$		Scott (2001)	
10	10	6			**Copper**	*Organo-copper compounds: Formates*	Copper(II) formate hydroxide (Compound F)		$Cu(HCOO)_2.Cu(OH)_2$		Scott (2001)	
10	10	7			**Copper**	*Organo-copper compounds: Formates*	Copper(II) formate hydroxide (Compound G)		$Cu(HCOO)_2.2Cu(OH)_2$		Scott (2001)	
10	10	8			**Copper**	*Organo-copper compounds: Acetates*	Copper(II) acetate hydroxide hydrate (Compound A)		$[Cu(CH_3COO)_2]_2.Cu(OH)_2.5H_2O$		Gauthier (1958); Schweizer & Mühlethaler (1968); Rahn-Koltermann et al. (1991); Kühn (1993); Scott (2001)	
10	10	9			**Copper**	*Organo-copper compounds: Acetates*	Copper(II) acetate hydroxide hydrate (Compound B)		$Cu(CH_3COO)_2.Cu(OH)_2.5H_2O$		Gauthier (1958); Schweizer & Mühlethaler (1968); Rahn-Koltermann et al. (1991); Kühn (1993); Scott (2001)	
10	10	10			**Copper**	*Organo-copper compounds: Acetates*	Copper(II) acetate hydroxide (Compound C)		$Cu(CH_3COO)_2.[Cu(OH)_2]_2$		Gauthier (1958); Schweizer & Mühlethaler (1968); Rahn-Koltermann et al. (1991); Kühn (1993); Scott (2001)	
10	10	11			**Copper**	*Organo-copper compounds: Acetates*	Copper(II) acetate hydroxide hydrate (Compound D)		$Cu(CH_3COO)_2.[Cu(OH)_2]_3.2H_2O$		Gauthier (1958); Schweizer & Mühlethaler (1968); Rahn-Koltermann et al. (1991); Kühn (1993); Scott (2001)	
10	10	12			**Copper**	*Organo-copper compounds: Acetates*	Copper(II) acetate (Compound E)		$Cu(CH_3COO)_2$	142-71-2	Gauthier (1958); Schweizer & Mühlethaler (1968); Rahn-Koltermann et al. (1991); Kühn (1993); Scott (2001)	
10	10	13			**Copper**	*Organo-copper compounds: Acetates*	Copper(II) acetate hydrate (Compound F)		$Cu(CH_3COO)_2.H_2O$		Gauthier (1958); Schweizer & Mühlethaler (1968); Rahn-Koltermann et al. (1991); Kühn (1993); Scott (2001)	
10	10	14			**Copper**	*Organo-copper compounds: Acetates*	Copper(I) acetate (Compound G)		$Cu(CH_3COO)$	4180-12-5	Gauthier (1958); Schweizer & Mühlethaler (1968); Rahn-Koltermann et al. (1991); Kühn (1993); Scott (2001)	
10	10	15			**Copper**	*Organo-copper compounds: Acetates*	Copper(II) acetate hydroxide hydrate (Compound H)		$Cu(CH_3COO)_2.[Cu(OH)_2]_4.3H_2O$		Gauthier (1958); Schweizer & Mühlethaler (1968); Rahn-Koltermann et al. (1991); Kühn (1993); Scott (2001)	
10	10	16			**Copper**	*Organo-copper compounds: Acetates*	Copper(II) potassium acetate		$2K(CH_3COO).Cu(CH_3COO)_2$		Orna (1996)/Scott (2001)	
10	10	17			**Copper**	*Organo-copper compounds: Acetates*	Ammonium copper acetate acetic acid		'$C_{14}H_{50}CuN_4O_{20}$'		Orna (1996)/Scott (2001)	
10	10	18			**Copper**	*Organo-copper compounds: Citrates*	Copper(II) citrate		$Cu_4[HOC(CH_2COO)_2(COO)]_2$		Turner (1998) from Alcherius/Lebegue (Merrifield (1849)); Scott (2001) from Paduan MS. (Merrifield (1849))	
10	10	19			**Copper**	*Organo-copper compounds: Tartrates*	Copper(II) tartrate hydrate				Turner (1998) from Alcherius/Lebegue (Merrifield (1849)); *Practical Treatise* (1795); de Massoul (1797)	
10	10	20			**Copper**	*Organo-copper compounds: Oxalates*	Copper(II) oxalate		CuC_2O_4	5893-66-3	Wainwright et al. (1997)	Tentative identification; probably alteration product
10	10	21			**Copper**	*Organo-copper compounds with fatty acids*	Copper azelate[3]					
10	10	21			**Copper**	*Organo-copper compounds with fatty acids*						
10	10	21			**Copper**	*Organo-copper compounds with fatty acids*	Copper laurate					
10	10	21			**Copper**	*Organo-copper compounds with fatty acids*	Copper myristate					
10	10	21			**Copper**	*Organo-copper compounds with fatty acids*	Copper palmitate					
10	10	21			**Copper**	*Organo-copper compounds with fatty acids*	Copper palmitoleate					
10	10	21			**Copper**	*Organo-copper compounds with fatty acids*	Copper stearate					
10	10	21			**Copper**	*Organo-copper compounds with fatty acids*	Copper oleate					
10	10	21			**Copper**	*Organo-copper compounds with fatty acids*	Copper linoleate					
10	10	21			**Copper**	*Organo-copper compounds with fatty acids*	Copper linolenate					
10	10	21	1		**Copper**	*Organo-copper compounds with fatty acids*	Copper salts of linseed oil (extract of seeds of *Linum usitatissimum*)[4]				Widely recognized; e.g., Birelli (1601) 369-70	
10	10	21	2		**Copper**	*Organo-copper compounds with fatty acids*	Copper salts of poppy oil (extract of seeds of *Papaver somniferum*)					

[3] The following 'pure' copper salts of fatty and other organo-acids are primarily for reference purposes; presumably the actual chemistry is somewhat more complex and subject to alteration *in vivo*.
[4] Copper salts of oils such as linseed, poppy and walnut should contain a range of fatty acids in accordance with the distribution found in the originating oil.

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α	β	γ	δ	ε	GROUP	SUB-GROUP	CHEMICAL NAME	VARIANT FORM	CHEMICAL FORMULA	CAS Number	LITERATURE	Notes
10	10	21	3		**Copper**	*Organo-copper compounds with fatty acids*	Copper salts of walnut oil (extract of fruit of *Juglans regia*)					
10	10	21	4		**Copper**	*Organo-copper compounds with fatty acids*	Copper salts of beeswax				Daniels (*pers. comm.*, 2001)	Use in Dynastic Egyptian context
10	10	22			**Copper**	*Organo-copper compounds with proteins*	[Copper proteinates]					
10	10	23			**Copper**	*Organo-copper compounds with resin acids*	[Copper resinates]					
11	1	1			**Gold**	*Gold*	Gold		Au	7440-57-5	Widely recognized	
11	1	2			**Gold**	*Gold*	Gold colloid (‘Purple of Cassius’)		Au adsorbed on to SnO_2 in a vitreous matrix		Cassius (1685); Osborn (1845); Salter (1869)	
11	2				**Gold**	*Carbonates*						
11	3				**Gold**	*Cyanides*						
11	4				**Gold**	*Halides*						
11	5				**Gold**	*Nitrates*						
11	6				**Gold**	*Oxides & hydroxides*						
11	7				**Gold**	*Phosphates*						
11	8	1			**Gold**	*Sulfides*	Gold silver sulfide		Au-Ag-S		Frantz & Schorsch (1990); Hatchfield & Newman (1991)	‘Egyptian red gold’
11	9				**Gold**	*Sulfates*						
11	10				**Gold**	*Organo-gold compounds*						
12	1				**Indium**	*Element*						
12	2				**Indium**	*Carbonates*						
12	3				**Indium**	*Cyanides*						
12	4				**Indium**	*Halides*						
12	5				**Indium**	*Nitrates*						
12	6	1			**Indium**	*Oxides & hydroxides*	Indium oxide		In_2O_3	1312-43-2	Salter (1869) under ‘Indium yellow’	
12	7				**Indium**	*Phosphates*						
12	8	1			**Indium**	*Sulfides*	Indium sulfide		In_2S_3	12030-24-9	Salter (1869) as ‘Indium yellow’	
12	9				**Indium**	*Sulfates*						
12	10				**Indium**	*Organo-indium compounds*						
13	1	1			**Iron**	*Iron*	Iron-chromium alloys (‘stainless steel’)		[Fe,Cr]		Bieganska et al (1988) as metal flake pigment	
13	2	1	1		**Iron**	*Carbonates*	Iron carbonate, siderite type		$FeCO_3$		Synthetic analogue	
13	2	1	2		**Iron**	*Carbonates*	Siderite		$FeCO_3$		Watchman et al. (in press)	
13	3				**Iron**	*Cyanides*						
13	4				**Iron**	*Halides*						
13	5				**Iron**	*Nitrates*						
13	6	1	1		**Iron**	*Oxides & hydroxides*[5]	Iron oxide hydroxide, akaganeite type		β-FeOOH		Cornell & Schwertmann (1996)	
13	6	1	2		**Iron**	*Oxides & hydroxides*	Akaganeite		β-FeOOH	12134-57-5	Cornell & Schwertmann (1996)	
13	6	2	1		**Iron**	*Oxides & hydroxides*	Iron oxide hydroxide, feroxyhyte type		δ'-FeOOH		Cornell & Schwertmann (1996)	
13	6	2	2		**Iron**	*Oxides & hydroxides*	Feroxyhyte		δ'-FeOOH	60497-39-4	Cornell & Schwertmann (1996)	
13	6	3	1		**Iron**	*Oxides & hydroxides*	Iron hydroxide, goethite type		α-FeOOH		Cornell & Schwertmann (1996)	
13	6	3	2		**Iron**	*Oxides & hydroxides*	Goethite		α-FeOOH	1310-14-1	Cornell & Schwertmann (1996)	
13	6	4	1		**Iron**	*Oxides & hydroxides*	Iron hydroxide, lepidocrocite type		γ-FeOOH		Cornell & Schwertmann (1996)	
13	6	4	2		**Iron**	*Oxides & hydroxides*	Lepidocrocite		γ-FeOOH	12022-37-6	Cornell & Schwertmann (1996)	
13	6	5	1		**Iron**	*Oxides & hydroxides*	Iron oxide hydrate, ferrihydrite type		$Fe_5HO_8{\cdot}4H_2O$		Cornell & Schwertmann (1996)	
13	6	5	2		**Iron**	*Oxides & hydroxides*	Ferrihydrite		$Fe_5HO_8{\cdot}4H_2O$		Cornell & Schwertmann (1996)	
13	6	6	1		**Iron**	*Oxides & hydroxides*	Iron oxide, hematite type		γ-Fe_2O_3		Cornell & Schwertmann (1996)	
13	6	6	2		**Iron**	*Oxides & hydroxides*	Hematite		γ-Fe_2O_3	1317-60-8	Cornell & Schwertmann (1996)	
13	6	7	1		**Iron**	*Oxides & hydroxides*	Iron oxide, maghemite type		γ-Fe_2O_3		Cornell & Schwertmann (1996)	
13	6	7	2		**Iron**	*Oxides & hydroxides*	Maghemite		γ-Fe_2O_3		Cornell & Schwertmann (1996)	
13	6	8	1		**Iron**	*Oxides & hydroxides*	Iron oxide, magnetite type		Fe_3O_4	1317-61-9	Cornell & Schwertmann (1996)	
13	6	8	2		**Iron**	*Oxides & hydroxides*	Magnetite		Fe_3O_4	1309-38-2	Cornell & Schwertmann (1996)	
13	6	9	1		**Iron**	*Tertiary oxides & hydroxides*	Iron aluminium oxide, hercynite type		$FeAl_2O_4$		Synthetic analogue	
13	6	9	2		**Iron**	*Tertiary oxides & hydroxides*	Hercynite		$FeAl_2O_4$		Stos-Fertner et al. (1979)	
13	6	10	1		**Iron**	*Tertiary oxides & hydroxides*	Iron manganese oxide, jacobsite type		$MnFe_2O_4$	12063-10-4	Schweizer & Rinuy (1982)	
13	6	10	2		**Iron**	*Tertiary oxides & hydroxides*	Jacobsite		$MnFe_2O_4$		Mineral analogue	
13	6	11			**Iron**	*Tertiary oxides & hydroxides*	Iron titanate		$FeTiO_3$	12022-71-8	Heaton (1928), Buxbaum (1998)	
13	6	12			**Iron**	*Tertiary oxides & hydroxides*	Ilmenite		$FeTiO_3$	12168-52-4	Heaton (1928), Buxbaum (1998)	
13	6	13			**Iron**	*Tertiary oxides & hydroxides*	Titanomagnetite		Fe_3O_4- Fe_2TiO_4		Jaksch et al. (1983)	As phase in Egyptian blue
13	6	14			**Iron**	*Tertiary oxides & hydroxides*	Iron zinc oxide		$ZnFe_2O_4$	12063-19-3	*Colour Index* (1971) PY 119	
13	7	1	1		**Iron**	*Phosphates*	Iron phosphate hydrate, vivianite type		[---]		Synthetic analogue	
13	7	1	2		**Iron**	*Phosphates*	Vivianite		$Fe_3(PO_4)_2{\cdot}8H_2O$	14567-67-0	Field (1835) and others; Filatov et al. (1965) and others	
13	8	1			**Iron**	*Sulfides*	Pyrite		FeS_2	1309-36-0	Funders & Möller (1989)	
13	8	2			**Iron**	*Sulfides*	Marcasite		FeS_2	1317-66-4	Related mineral	
13	9	1	1		**Iron**	*Sulfates*	Iron sulfate hydrate		$FeSO_4.7H_2O$	7782-63-0	Hsu Wei-yeh et al. (1983) (?)	
13	9	1	2		**Iron**	*Sulfates*	Melanterite		$FeSO_4.7H_2O$		Watchman et al. (in press)	

[5] There are a number of other iron oxides and hydroxides of lesser significance listed by Cornell & Schwertmann: $Fe(OH)_2$, FeO (wüstite), a β-Fe_2O_3, a ε-Fe_2O_3, a high-pressure FeOOH, a ferrimagnetic δ-FeOOH and a crystalline $Fe(OH)_3$ (bernalite). There is also a group of Fe^{III}-oxy-hydroxy salts that are closely related to the oxides, including the oxy-hydroxy sulfate schwertmannite and an oxy-hydroxy nitrate. Some of these may also occur in a pigment context.

α	β	γ	δ	ε	GROUP	SUB-GROUP	CHEMICAL NAME	VARIANT FORM	CHEMICAL FORMULA	CAS Number	LITERATURE	Notes
13	9	2			**Iron**	*Sulfates*	Hydronium-jarosite		$Fe_3(SO_4)_2(OH)_5.2H_2O$		Wallert (1995); present authors in pigments from Pompeii (unpublished)	Also known as ‘carphosiderite’
13	9	3			**Iron**	*Sulfates*	Jarosite		$KFe_3(SO_4)_2(OH)_6$	12449-90-0	Reindell & Riederer (1978); El Goresy et al. (1986); Wallert (1995); Colinart (1998); present authors in pigments from Pompeii (unpublished)	
13	9	4			**Iron**	*Sulfates*	Natrojarosite		$NaFe_3(SO_4)_2(OH)_6$	12449-96-6	Related mineral	
13	10	1	1		**Iron**	*Organo-iron compounds*	Iron(II) oxalate		$Fe(C_2O_4)$	516-03-0	Salter (1869) as ‘Iron yellow (oxalate of protoxide of iron)’?	
13	10	1	2		**Iron**	*Organo-iron compounds*	Humboldtine		$Fe^{2+}C_2O_4.2H_2O$	6047-25-2	Mineral form by association	
14	1	1			**Lead**	*Lead*	Lead		Pb	7439-92-1	Dunn (1975)	
14	2	1	1		**Lead**	*Carbonates*	Lead carbonate		$PbCO_3$	598-63-0	Widely recognised	
14	2	1	2		**Lead**	*Carbonates*	Cerussite		$PbCO_3$	14476-15-4	Mineral form by association	
14	2	2			**Lead**	*Carbonates*	Lead carbonate hydroxide		$PbCO_3.Pb(OH)_2$		Zhou Guoxin et al. (1997)	
14	2	3			**Lead**	*Carbonates*	Lead carbonate hydroxide hydrate		$PbCO_3.Pb(OH)_2.H_2O$		Zhou Guoxin et al. (1997)	
14	2	4	1	1	**Lead**	*Carbonates*	Lead carbonate hydroxide	From the ‘Stack’ process	$2PbCO_3.Pb(OH)_2$	1319-46-6	Widely recognized	
14	2	4	1	2	**Lead**	*Carbonates*	Lead carbonate hydroxide	*et. seq.* From other processes (to be defined)	$2PbCO_3.Pb(OH)_2$	1319-46-6	Widely recognized	
14	2	4	2		**Lead**	*Carbonates*	Hydrocerussite		$2PbCO_3.Pb(OH)_2$	1319-47-7	Mineral form by association	
14	2	5			**Lead**	*Carbonates*	Lead carbonate hydroxide hydrate		$2PbCO_3.Pb(OH)_2.H_2O$		Zhou Guoxin et al. (1997)	
14	2	6			**Lead**	*Carbonates*	Lead carbonate hydroxide		$3PbCO_3.2Pb(OH)_2$		Keisch (1972); Katz & Lefker (1957); Mauch & Brunold (1957)	
14	2	7			**Lead**	*Carbonates*	Lead carbonate hydroxide hydrate		$3PbCO_3.2Pb(OH)_2.H_2O$		Zhou Guoxin et al. (1997)	
14	2	8			**Lead**	*Carbonates*	Lead carbonate hydroxide oxide		$4PbCO_3.2Pb(OH)_2.PbO$		Keisch (1972); Thompson & Stewart (1940); Stewart (1950)	
14	2	9	1		**Lead**	*Carbonates*	Lead carbonate hydroxide oxide, plumbonacrite type		$6PbCO_3.3Pb(OH)_2.PbO$		Tétreault et al (1998)	
14	2	9	2		**Lead**	*Carbonates*	Plumbonacrite		$6PbCO_3.3Pb(OH)_2.PbO$		Mineral analogue	
14	3	1			**Lead**	*Cyanides*	Lead cyanide		$Pb(CN)_2$	592-05-2	*Colour Index* (1971) 77610	
14	4	1	1		**Lead**	*Halides*	Lead chloride, cotunnite type		$PbCl_2$		Naruse (1996)	
14	4	1	2		**Lead**	*Halides*	Cotunnite		$PbCl_2$		Naruse (1996)	
14	4	2	1		**Lead**	*Halides*	Lead chloride carbonate		[---]		Hsu Wei-yeh et al. (1983)	
14	4	2	1		**Lead**	*Halides*	Lead chloride hydroxide, blixite type		$Pb_2Cl(O,OH)_{2-x}$, x = ~ 0.3		Winter (1981)	
14	4	2	2		**Lead**	*Halides*	Blixite		$Pb_2Cl(O,OH)_{2-x}$, x = ~ 0.3		Winter (1981)	
14	4	3	1		**Lead**	*Halides*	Lead chloride hydroxide, fiedlerite type		$Pb_3Cl_4(OH)_2$		Noble & Wadum (1998)	
14	4	3	2		**Lead**	*Halides*	Fiedlerite		$Pb_3Cl_4(OH)_2$		Noble & Wadum (1998)	
14	4	4	1		**Lead**	*Halides*	Lead chloride hydroxide, laurionite type		PbCl(OH)	15887-88-4	Winter (1981) Disc. Patterson, 1844, as ‘Patterson’s white’ (cf. *Colour Index* (1971) 77593)	
14	4	4	2		**Lead**	*Halides*	Laurionite		PbCl(OH)		Winter (1981); Naruse (1996); Zhou Guoxin et al. (1997)	
14	4	5			**Lead**	*Halides*	Paralaurionite		PbCl(OH)		Related mineral form	
14	4	6			**Lead**	*Halides*	Lead chloride oxide		$PbCl_{2.5-7}PbO$	12182-67-1	Disc. Turner, 1781; then, e.g., Bersch (1901), *Colour Index* (1971) 77592	‘Turner’s’ or ‘Patent’ yellow
							Lead bismuth chloride oxide		$(Pb,Bi)_2Cl_{2.5-7}O$ (?)		Merimée (1830) 108-109	
14	4	7	1		**Lead**	*Halides*	Lead chloride oxide, mendipite type		$Pb_3Cl_2O_2$	12205-70-8	Mineral form by association	
14	4	7	2		**Lead**	*Halides*	Mendipite		$Pb_3Cl_2O_2$		Mineral form by association	
14	4	8			**Lead**	*Halides*	Lead chlorosulfite (Lead chloride sulfite??)				‘Caledonian white’? (Mayer (1991))	
14	4	9			**Lead**	*Halides*	Lead iodide		PbI_2	10101-63-0	*Colour Index* (1971) 77613	
14	5				**Lead**	*Nitrates*						
14	6	1	1		**Lead**	*Oxides & hydroxides*	Lead(II) oxide, litharge type		PbO	1317-36-8	Burgio et al (1998); Duang et al (1987); Le Fur (1990); Mairinger & Schreiner (1986); Preusser et al (1981); Wang et al (1993a, b); Yamasaki (1957); Yamasaki (1972)	
14	6	1	2		**Lead**	*Oxides & hydroxides*	Litharge		PbO	1317-36-8	[As above]	
14	6	2	1		**Lead**	*Oxides & hydroxides*	Lead(II) oxide, massicot type		PbO	1317-36-8	Filatov et al (1965); Le Fur (1990); Mairinger & Schreiner (1986); Nord & Tronner (1998); Preusser et al (1981); Riederer (1977b)	
14	6	2	2		**Lead**	*Oxides & hydroxides*	Massicot		PbO	1317-36-8	[As above]	
14	6	3	1		**Lead**	*Oxides & hydroxides*	Lead(IV) oxide		PbO_2	1309-60-0	Wang et al (1993b)	
14	6	3	2		**Lead**	*Oxides & hydroxides*	Plattnerite		PbO_2		Wainwright et al. (1997)	Probably as alteration product of lead(II,IV) oxide/minium
14	6	4	1	1	**Lead**	*Oxides & hydroxides*	Lead(II,IV) oxide	By thermal conversion of another lead oxide	$2PbO.PbO_2$	1314-41-6	Widely recognized; rev.: FitzHugh (1986)	CI Pigment Red 105
14	6	4	1	2	**Lead**	*Oxides & hydroxides*	Lead(II,IV) oxide	‘Fumed’	$2PbO.PbO_2$		Widely recognized; rev.: FitzHugh (1986)	
14	6	4	2		**Lead**	*Oxides & hydroxides*	Minium		$2PbO.PbO_2$	1314-41-6	Forbes and Petrie, cf. FitzHugh (1986)	
14	6	5			**Lead**	*Oxides & hydroxides*	Lead hydroxide		$Pb_3O_2(OH)_2$			
14	6	6			**Lead**	*Oxides & hydroxides*	Lead oxide		[CI also lists a Pb_2O_3 – ($PbO.PbO_2$?)]	1314-27-8	*Colour Index* (1971)	
14	6	7			**Lead**	*Tertiary, quaternary & higher oxides*	Lead aluminium oxide		$PbO.Al_2O_3$	1345-29-5	*Colour Index* (1971) 77585	
14	6	8	1		**Lead**	*Tertiary, quaternary & higher oxides*	Lead antimony oxide, bindheimite type		$Pb_2Sb_2O_7$ (or $Pb_ySb_{2-x}O_7$, where $0 \leq x \leq 1$ and $2 \leq y \leq 3$)	15578-55-9	Widely recognized, review Wainwright et al. (1993)	
14	6	8	2		**Lead**	*Tertiary, quaternary & higher oxides*	Bindheimite		$Pb_2Sb_2O_7$		Related mineral form	

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α	β	γ	δ	ε	GROUP	SUB-GROUP	CHEMICAL NAME	VARIANT FORM	CHEMICAL FORMULA	CAS Number	LITERATURE	Notes
14	6	9			**Lead**	*Tertiary, quaternary & higher oxides*	Lead antimony oxide, rosiaite type		$PbSb_2O_6$		Wainwright et al. (1986)	Hexagonal crystal system
14	6	10			**Lead**	*Tertiary, quaternary & higher oxides*	Rosiaite		$PbSb_2O_6$		Related mineral form	Trigonal crystal system
14	6	11			**Lead**	*Tertiary, quaternary & higher oxides*	Lead antimony tin oxide		$Pb_2SbSnO_{6.5}$		Cascales et al. (1986); Roy & Berry (1998)	
14	6	12			**Lead**	*Tertiary, quaternary & higher oxides*	Lead antimony zinc oxide		$Pb(Sb_x,Zn_{1-x})O_3$?		Riffault et al. (1874)	
14	6	13	1		**Lead**	*Tertiary, quaternary & higher oxides*	Lead arsenate, schultenite type		$PbHAsO_4$	7784-40-9	Related compound	
14	6	13	2		**Lead**	*Tertiary, quaternary & higher oxides*	Schultenite		$PbHAsO_4$	14758-11-3	Related mineral	
14	6	14			**Lead**	*Tertiary, quaternary & higher oxides*	Lead diarsenate (V)		$PbAs_2O_6$	8464-43-2	Related compound	
14	6	15			**Lead**	*Tertiary, quaternary & higher oxides*	Lead arsenate		$Pb_3As_4O_2$	3687-31-8	Salter (1869) 116 as 'Arsenic yellow', then chem. lit.	
14	6	16			**Lead**	*Tertiary, quaternary & higher oxides*	Lead pyroarsenate		Pb_2AsO_7	13510-94-6	Salter (1869) 116 as 'Arsenic yellow', then chem. lit.	
14	6	17	2		**Lead**	*Tertiary, quaternary & higher oxides*	Mimetite		$Pb_5(AsO_4)_3Cl$		Rouveret & Walter (1998)	
14	6	18			**Lead**	*Tertiary, quaternary & higher oxides*	Lead iron arsenate (?)		'Pb,Fe(Sb,Zn) arsenate'		Meggiolaro et al. (1997)	Tentative identification on Corintihian wallpaintings of the mid-1st century
14	6	19			**Lead**	*Tertiary, quaternary & higher oxides*	Lead tin oxide		Pb_2SnO_4		Widely recognized, review Kühn (1968/1993)	
14	6	20			**Lead**	*Tertiary, quaternary & higher oxides*	Lead silicon tin oxide		$Pb(Si_x,Sn_{1-x})O_3$		Widely recognised, review Kühn (1968/1993)	
14	6	21			**Lead**	*Tertiary, quaternary & higher oxides*	Lead antimony bismuth oxide		[---]		*Colour Index* (1971) 77589	
14	6	22			**Lead**	*Tertiary, quaternary & higher oxides*	Lead antimony bismuth zinc oxide		[---]		*Colour Index* (1971) 77589	
14	7	1			**Lead**	*Phosphates*	Lead phosphate		$Pb_9(PO_4)_6$		Winter (1981)	
14	7	2			**Lead**	*Phosphates*	Lead phosphate hydroxide		$Pb_5(PO_4)_3OH$	12207-55-5	Related compound [Apatite group, Naruse (1996)]	
14	7	2			**Lead**	*Phosphates*	Hydroxypyromorphite		$Pb_5(PO_4)_3OH$		Béarat (1995)	
14	7	2			**Lead**	*Phosphates*	Pyromorphite		$Pb_5(PO_4)_3Cl$		Béarat (1995) [Apatite group, Naruse (1996)]	
14	7	3			**Lead**	*Phosphates*	Lead phosphate fluoride		$Pb_5(PO_4)_3F$		Related compound [Apatite group, Naruse (1996)]	
14	7	4			**Lead**	*Phosphates*	Lead oxide phosphite hydrate		$2PbO.PbHPO_3.0.5H_2O$		Dunn (1973a) 81	
14	8	1			**Lead**	*Sulfides*	Galena		PbS	1314-87-0	Field (1835); Dunn (1973a)	
14	9	1	1		**Lead**	*Sulfates & sulfites*	Lead sulfate		$PbSO_4$	7446-14-2	Dunn (1973a)	
14	9	1	2		**Lead**	*Sulfates & sulfites*	Anglesite		$PbSO_4$	14594-79-7	Piqué (1997)	
14	9	2	1		**Lead**	*Sulfates & sulfites*	Lead oxide sulfate		$PbSO_4.PbO$		Dunn (1973a)	
14	9	2	2		**Lead**	*Sulfates & sulfites*	Lanarkite		$Pb_2(SO_4)O$		Related mineral	
14	9	3			**Lead**	*Sulfates & sulfites*	Lead oxide sulfate		$PbSO_4.2PbO$		Dunn (1973a)	
14	9	4			**Lead**	*Sulfates & sulfites*	Lead oxide sulfate		$PbSO_4.3PbO$		Dunn (1973a)	
14	9	5			**Lead**	*Sulfates & sulfites*	Lead oxide sulfate hydrate		$PbSO_4.3PbO.H_2O$		Dunn (1973a)	
14	9	6			**Lead**	*Sulfates & sulfites*	Lead oxide sulfate		$PbSO_4.4PbO$	12065-90-6	Dunn (1973a)	
14	9	7			**Lead**	*Sulfates & sulfites*	Lead sulfite hydroxide		$3PbSO_3.Pb(OH)_2$		Brochwicz et al (1993) as 'sulfite white'	
14	9	8			**Lead**	*Sulfates & sulfites*	Lead sulfate hydroxide		$2PbSO_4.Pb(OH)_2$		Brochwicz et al (1993) as 'Mulhauser's white'	
14	9	9	1		**Lead**	*Sulfates & sulfites*	Lead sulfate carbonate hydroxide, leadhillite type		$PbSO_4.2PbCO_3.Pb(OH)_2$		Synthetic analogue	
14	9	9	2		**Lead**	*Sulfates & sulfites*	Leadhillite		$PbSO_4.2PbCO_3.Pb(OH)_2$		Zhou Guoxin et al. (1997)	
14	10	1			**Lead**	*Organo-lead compounds*	Lead(II) acetate trihydrate		$Pb(CH_3COO)_2.3H_2O$	6080-56-4	Tétreault et al (1998) [Unstable corrosion product]	
14	10	2			**Lead**	*Organo-lead compounds*	Lead acetate oxide hydrate		$Pb(CH_3CO_2)_2.2PbO.H_2O$		Tétreault et al (1998) [Unstable corrosion product]	
14	10	3			**Lead**	*Organo-lead compounds*	Lead acetate oxide hydrate		$Pb_3(CH_3CO_2)_6.PbO.H_2O$		Tétreault et al (1998) [Unstable corrosion product]	
14	10	4			**Lead**	*Organo-lead compounds*	Lead citrate		$Pb(C_6H_5O_7)_2.3H_2O$	512-26-5	Toch (1916) 82	Formed when treating lead chromate pigments with organic acids to create paler shades
14	10	5			**Lead**	*Organo-lead compounds*	Lead tartrate		$PbC_4H_4O_6.H_2O$		Toch (1916) 82	Formed when treating lead chromate pigments with organic acids to create paler shades
15	1				**Magnesium**	*Magnesium*						
15	2	1	1		**Magnesium**	*Carbonates*	Magnesium carbonate		$MgCO_3$	546-93-0	Synthetic analogue	
15	2	1	2		**Magnesium**	*Carbonates*	Magnesite		$MgCO_3$	13717-00-5	Terry (1893); Heaton (1928), Newton & Sharp (1987)	
15	2	2			**Magnesium**	*Carbonates*	Magnesium carbonate hydroxide hydrate		$5MgCO_3.Mg(OH)_2.3H_2O$		Related compound	
15	2	3			**Magnesium**	*Carbonates*	Hydromagnesite		$Mg_5(CO_3)_4(OH)_2{\cdot}4H_2O$		Garavelli et al. (1990)	
15	2	4			**Magnesium**	*Carbonates*	Magnesium carbonate hydroxide hydrate		$5MgCO_3.2Mg(OH)_2.7H_2O$		Related compound	
15	2	5			**Magnesium**	*Carbonates*	Magnesium carbonate hydroxide		$4MgCO_3.Mg(OH)_2$		Related compound	
15	2	6			**Magnesium**	*Carbonates*	Magnesium carbonate hydroxide hydrate		$3MgCO_3.Mg(OH)_2.4H_2O$		Related compound	
15	3				**Magnesium**	*Cyanides*						
15	4	1			**Magnesium**	*Halides*	Magnesium chloride hydroxide				Watchman et al. (in press)	
15	5				**Magnesium**	*Nitrates*						
15	6	1	1		**Magnesium**	*Oxides & hydroxides*	Magnesium oxide, periclase type		MgO	1309-48-4	Possibly Laurie (1914) (*cf.* Fielder & Bayard (1986))	
15	6	1	2		**Magnesium**	*Oxides & hydroxides*	Periclase		MgO	1317-74-4	Newton & Sharp (1987)	
15	6	2			**Magnesium**	*Oxides & hydroxides*	Magnesium iron oxide		(Mg,Fe)O		*Colour Index* (1971) Pigment Brown 11	
15	7				**Magnesium**	*Phosphates*						
15	8				**Magnesium**	*Sulfides*						

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α	β	γ	δ	ε	GROUP	SUB-GROUP	CHEMICAL NAME	VARIANT FORM	CHEMICAL FORMULA	CAS Number	LITERATURE	Notes
15	9				**Magnesium**	*Sulfates*						
15	10	1			**Magnesium**	*Organo-magnesium compounds*	Magnesium oxalate hydrate		$MgC_2O_4.H_2O$	547-66-0	Watchman et al. (in press)	
16	1				**Manganese**	*Manganese*						
16	2	1	1		**Manganese**	*Carbonates*	Manganese carbonate		$MnCO_3$	598-62-9	*Colour Index* (1971) 77733	
16	2	1	2		**Manganese**	*Carbonates*	Rhodochrosite		$MnCO_3$	14476-12-1	Related mineral form	
16	3				**Manganese**	*Cyanides*						
16	4				**Manganese**	*Halides*						
16	5				**Manganese**	*Nitrates*						
16	6	1	1		**Manganese**	*Oxides & hydroxides*	Manganese(II) oxide		MnO	1344-43-0		
16	6	1	2		**Manganese**	*Oxides & hydroxides*	Manganosite		MnO	1313-12-8		
16	6	2			**Manganese**	*Oxides & hydroxides*	Bixbyite		$(Mn^{3+},Fe^{3+})_2O_3$		Schweizer & Rinuy (1982); Nirmaier (2000)	Empirically: $Mn_{1.5}Fe_{0.5}O_3$
16	6	3			**Manganese**	*Oxides & hydroxides*	Manganese(III) oxide		Mn_2O_3	1317-34-6		
16	6	4	1		**Manganese**	*Oxides & hydroxides*	Manganese(IV) oxide, pyrolusite type		MnO_2	1313-13-9		
16	6	4	2		**Manganese**	*Oxides & hydroxides*	Pyrolusite		MnO_2	14854-26-3		
16	6	5	1		**Manganese**	*Oxides & hydroxides*	Manganese(II,III) oxide, hausmannite type		$Mn^{II}Mn_2^{III}O_4$	1317-35-7		
16	6	5	2		**Manganese**	*Oxides & hydroxides*	Hausmannite		$Mn^{II}Mn_2^{III}O_4$	1309-55-3	Nirmaier (2000)	
16	6	6			**Manganese**	*Oxides & hydroxides*	Manganese(II) hydroxide		$Mn(OH)_2$			
16	6	7			**Manganese**	*Oxides & hydroxides*	Manganese(III) hydroxide		$Mn(OH)_3$			
16	6	8			**Manganese**	*Oxides & hydroxides*	Manganite (??)		MnO(OH)			
16	6	9			**Manganese**	*Oxides & hydroxides*	Manganese(II,IV) oxide hydrate		$MnO.MnO_2.H_2O$			
16	6	10			**Manganese**	*Oxides & hydroxides*	Manganese oxide hydroxide		MnO(OH)	12025-99-9		
16	7	1	1		**Manganese**	*Phosphates*	Manganese(III) phosphate		$MnPO_4$	14986-93-7	Synthetic analogue	
16	7	1	2		**Manganese**	*Phosphates*	Purpurite		$MnPO_4$ or $(Mn,Fe)PO_4$		Currently available from Kremer Pigmente, Germany	
16	7	2			**Manganese**	*Phosphates*	Manganese iron phosphate hydrate		$2(Fe,Mn)PO_4.H_2O$			Older formula for purpurite; probably erroneous
16	7	3			**Manganese**	*Phosphates*	Manganese ammonium phosphate		$(NH_4)_2Mn_2(P_2O_7)_2$?			
16	8				**Manganese**	*Sulfides*						
16	9				**Manganese**	*Sulfates*						
16	10				**Manganese**	*Organo-manganese compounds*						
17	1				**Mercury**	*Mercury*						
17	2				**Mercury**	*Carbonates*						
17	3				**Mercury**	*Cyanides*						
17	4	1			**Mercury**	*Halides*	Mercury iodide, α- type		α-HgI_2	7774-29-0	Mérimée (1830) and others; Townsend (1993); chem.. lit.	
17	4	2			**Mercury**	*Halides*	Mercury iodide, β- type		β-HgI_2		Mérimée (1830) and others; Townsend (1993) ; chem.. lit.	
17	5				**Mercury**	*Nitrates*						
17	6	1			**Mercury**	*Oxides & hydroxides*	Mercury(II) oxide		HgO	21908-53-2	Salter (1869) 173 as 'Red precipitate'	
17	7				**Mercury**	*Phosphates*						
17	8	1	1	1	**Mercury**	*Sulfides*	Mercury(II) sulfide, cinnabar type	'Dry' process	HgS		Widely recognised	
17	8	1	1	2	**Mercury**	*Sulfides*	Mercury(II) sulfide, cinnabar type	'Wet' process	HgS		Widely recognised	
17	8	1	2		**Mercury**	*Sulfides*	Cinnabar		HgS		Widely recognised	
17	8	2	1		**Mercury**	*Sulfides*	Mercury(II) sulfide, hypercinnabar type		HgS			
17	8	2	2		**Mercury**	*Sulfides*	Hypercinnabar		HgS			
17	8	3	1		**Mercury**	*Sulfides*	Mercury(II) sulfide, metacinnabar type		HgS			
17	8	3	2		**Mercury**	*Sulfides*	Metacinnabar		HgS			
17	9	1			**Mercury**	*Sulfates*	Mercury sulfate		$HgSO_4$	7783-35-9	Related compound	
17	9	2			**Mercury**	*Sulfates*	Mercury sulfate hydroxide (?? Mercury oxide sulfate)		[---]		Harley (1982) and others as 'Turbith mineral'	
17	9	3			**Mercury**	*Sulfates*	Schuetteite [†]		$Hg_3SO_4O_2$		Related mineral	
17	10				**Mercury**	*Organo-mercury compounds*						
18	1				**Molybdenum**	*Molybdenum*						
18	2				**Molybdenum**	*Carbonates*						
18	3				**Molybdenum**	*Cyanides*						
18	4				**Molybdenum**	*Halides*						
18	5				**Molybdenum**	*Nitrates*						
18	6	1			**Molybdenum**	*Oxides*	Molybdenum (III) oxide		Mo_2O_3	1313-29-7	Bersch (1901)[6]; *Colour Index* (1971) 77769	
18	6	2			**Molybdenum**	*Oxides: molybdates*	Copper molybdate				Salter (1869) 289	
18	6	3	1		**Molybdenum**	*Oxides: molybdates*	Lead molybdate		$PbMoO_4$	10190-55-3	Related compound	
18	6	3	2		**Molybdenum**	*Oxides: molybdates*	Wulfenite		$PbMoO_4$	14913-82-7	Bimson (1980)	
18	6	4			**Molybdenum**	*Oxides: molybdates*	Tin molybdate		[---]		Bersch (1901)	
18	7				**Molybdenum**	*Phosphates*						
18	8				**Molybdenum**	*Sulfides*						
18	9				**Molybdenum**	*Sulfates*						
18	10				**Molybdenum**	*Organo-molybdenum compunds*						

[6] Bersch refers to the 'blue modification of molybdenum oxide' as a component (with 'stannic molybdate') in the pigment he calls *molybdenum blue*.

α	β	γ	δ	ε	GROUP	SUB-GROUP	CHEMICAL NAME	VARIANT FORM	CHEMICAL FORMULA	CAS Number	LITERATURE	Notes
19	1	1			**Nickel**	*Nickel*	Nickel		Ni	7440-02-0	Bieganska et al (1988) as metal flake pigment	
19	2				**Nickel**	*Carbonates*						
19	3				**Nickel**	*Cyanides*						
19	4				**Nickel**	*Halides*						
19	5				**Nickel**	*Nitrates*						
19	6				**Nickel**	*Oxides & hydroxides*						
19	7	1			**Nickel**	*Phosphates*	Nickel phosphate hydrate		$Ni_3(PO_4)_2.7H_2O$		Bersch (1901); *Colour Index* (1971)	
19	8				**Nickel**	*Sulfides*						
19	9				**Nickel**	*Sulfates*						
19	10				**Nickel**	*Organo-nickel compounds*						
20	1				**Palladium & platinum**	*Palladium &platinum*						
20	2				**Palladium & platinum**	*Carbonates*						
20	3				**Palladium & platinum**	*Cyanides*						
20	4	1			**Palladium & platinum**	*Halides*	Palladium ammonium chloride		[---]		*Colour Index* (1971) 77790 as 'Palladium red'	
20	4	2			**Palladium & platinum**	*Halides*	Potassium hexachloroplatinate(IV)		$K_2[PtCl_6]$	16921-30-5	Field (1835) and elsewhere as 'Platina yellow'; *Colour Index* (1971)	
20	5				**Palladium & platinum**	*Nitrates*						
20	6				**Palladium & platinum**	*Oxides & hydroxides*						
20	7				**Palladium & platinum**	*Phosphates*						
20	8				**Palladium & platinum**	*Sulfides*						
20	9				**Palladium & platinum**	*Sulfates*						
20	10				**Palladium & platinum**	*Organo-palladium/platinum compounds*						
21	1				**Silicon**	*Silicon*						
21	2				**Silicon**	*Carbonates*						
21	3				**Silicon**	*Cyanides*						
21	4				**Silicon**	*Halides*						
21	5				**Silicon**	*Nitrates*						
21	6	1	1		**Silicon (silica)**	*Oxides & hydroxides*	Silica, amorphous	From mineral source	SiO_2		Patton (1973)	Described as 'cryptocrystalline'
21	6	1	2		**Silicon (silica)**	*Oxides & hydroxides*	Silica, amorphous	From biogenic source (diatoms)	SiO_2		Widely recognized. Also: present authors in pigments from Pompeii (unpublished)	
21	6	1	3		**Silicon (silica)**	*Oxides & hydroxides*	Silica, amorphous	From mineralised biogenic source (diatomite)	SiO_2		Widely recognized. Also: present authors in pigments from Pompeii (unpublished)	
21	6	1	4		**Silicon (silica)**	*Oxides & hydroxides*	Silica, amorphous	From mineralised biogenic source (radiolarite)	SiO_2		Widely recognized. Also: present authors in pigments from Pompeii (unpublished)	
21	6	2			**Silicon (silica)**	*Oxides & hydroxides*	α-Quartz		SiO_2	14808-60-7	Widely recognized & chem./min. lit.	
21	6	3			**Silicon (silica)**	*Oxides & hydroxides*	β-Quartz		SiO_2	14808-60-7	Widely recognized & chem./min. lit.	
21	6	4			**Silicon (silica)**	*Oxides & hydroxides*	Tridymite		SiO_2	15468-32-3	Related mineral form	
21	6	5			**Silicon (silica)**	*Oxides & hydroxides*	Cristobalite		SiO_2	14464-46-1	Present authors in pigments from Pompeii (unpublished)	
21	6	6			**Silicon (silica)**	*Oxides & hydroxides*	Silica hydrate		$(SiO_2)_x{\cdot}(H_2O)_y$; $3 \leq x/y \leq 10$		Boland & Wagner (1973)	
21	7				**Silicon**	*Phosphates*						
21	8				**Silicon**	*Sulfides*						
21	9				**Silicon**	*Sulfates*						
21	10				**Silicon**	*Organo-silicon compounds*						
22	1	1			**Silicates**	*Amorphous silicates*	Glass		SiO_2(vit)			
22	1	2			**Silicates**	*Amorphous silicates*	Glass, cobalt doped		SiO_2(vit)Co_x		Widely recognized. Revs.: Riederer (1968); Mulethaler & Thissen (1993)	'Smalt'
22	2	1			**Silicates**	*Chain silicates*	Actinolite		$Ca_2(Mg,Fe^{2+})_5Si_8O_{22}(OH)_2$		*Colour Index* (1971) 77718	
22	2	2			**Silicates**	*Chain silicates*	Aegirine		$(Na,Fe^{3+})Si_2O_6$	14567-85-2	[Possible relict component in green earth]	Acmite
22	2	3	1		**Silicates**	*Chain silicates*	Lead silicate, alamosite type		$PbSiO_3$		*Colour Index* (1971) 77625/PW 16	
22	2	3	2		**Silicates**	*Chain silicates*	Alamosite		$PbSiO_3$		Related mineral	
22	2	4			**Silicates**	*Chain silicates*	Anthophyllite		$(Mg, Fe^{2+})_7Si_8O_{22}(OH)_2$		Type of asbestos (e.g., Heaton, 1928)	
22	2	5			**Silicates**	*Chain silicates*	Augite		$(Ca,Mg,Fe)_2Si_2O_6$		[Possible relict component in green earth]	
22	2	6			**Silicates**	*Chain silicates*	Calcium silicate hydrate		$(SiO_2)_x{\cdot}(CaO)_2{\cdot}(H_2O)_y$; $x/z \geq 3.3$		Boland & Wagner (1973)	
22	2	7			**Silicates**	*Chain silicates*	Calcium silicate hydrate		$CaSiO_3.nH_2O$		Kranich (1973)	
22	2	8			**Silicates**	*Chain silicates*	Calcium silicate		Ca_2SiO_4	1344-95-2	Lawrence (1960); *Colour Index* (1971); then chem./min. lit., e.g. Merck (1996)	
22	2	9			**Silicates**	*Chain silicates*	Calcium silicate		Ca_3SiO_5		Lawrence (1960); *Colour Index* (1971); then chem./min. lit., e.g. Merck (1996)	
22	2	10			**Silicates**	*Chain silicates*	Crossite		$Na_2(Mg,Fe^{2+})_3(Al,Fe^{3+})_2Si_8O_{22}(OH)_2$		Found in association with glaucophane. Cameron et al (1977); Filippakis et al (1976); Profi et al (1976)	
22	2	11			**Silicates**	*Chain silicates*	Diopside		$Mg,CaSi_2O_6$	13774-18-0	Plesters (1993) 49 as impurity with lazurite	

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α	β	γ	δ	ε	GROUP	SUB-GROUP	CHEMICAL NAME	VARIANT FORM	CHEMICAL FORMULA	CAS Number	LITERATURE	Notes
22	2	12			**Silicates**	*Chain silicates*	Enstatite		$Mg_2Si_2O_6$	13776-74-4	Related mineral (may occur as thermal modification of other magnesium silicates)	
22	2	13			**Silicates**	*Chain silicates*	Glaucophane		$Na_2(Mg,Fe^{2+})_3Al_2Si_8O_{22}(OH)_2$	12173-39-6	Cameron et al (1977); Filippakis et al (1976); Profi et al. (1976)	
22	2	14			**Silicates**	*Chain silicates*	Hornblende		$Ca_2(Mg,Fe^{2+})_4AlSi_7AlO_{22}(OH)_2$		Related to *Colour Index* (1971) 77718/Pigment White 26	
22	2	15			**Silicates**	*Chain silicates*	Jadeite		$Na(Al,Fe^{3+})Si_2O_6$	12003-54-2	[Precursor mineral for glaucophane]	
22	2	16			**Silicates**	*Chain silicates*	Riebeckite		$Na_2(Fe^{2+}Mg)_3(Fe_2^{3+})_2Si_8O_{22}(OH)_2$		Cameron et al. (1977); Filippakis et al. (1976); Profi et al. (1976)	
22	2	17			**Silicates**	*Chain silicates*	Tremolite		$Ca_2Mg_5Si_8O_{22}(OH)_2$	14567-73-8	*Colour Index* (1971) 77718	
22	2	18			**Silicates**	*Chain silicates*	Calcium silicate		$CaSiO_3$	1344-95-2	Lawrence (1960); *Colour Index* (1971); then chem./min. lit., e.g. Merck (1996)	See also: Wollastonite
22	2	18			**Silicates**	*Chain silicates*	Wollastonite, form 1		$CaSiO_3$	13983-17-0	Lawrence (1960); *Colour Index* (1971); then chem./min. lit. , e.g. Merck (1996)	
22	2	19			**Silicates**	*Chain silicates*	Wollastonite, form 2		$CaSiO_3$	14567-51-2	Lawrence (1960); *Colour Index* (1971); then chem./min. lit. , e.g. Merck (1996)	Para-wollastonite
22	2	20			**Silicates**	*Chain silicates*	Wollastonite, form 3		$CaSiO_3$	14567-52-3	Lawrence (1960); *Colour Index* (1971); then chem./min. lit. , e.g. Merck (1996)	Psuedo-wollastonite
22	2	21			**Silicates**	*Chain silicates*	Cupro-wollastonite		$(Ca,Cu)_3(Si_3O_9)$		Noll & Hangst (1975); Schilling (1988); Green (1995)	'Egyptian green'
22	3	1			**Silicates**	*Framework silicates*	Albite		$NaAlSi_3O_8$	12244-10-9	Duang et al (1987)	
22	3	2			**Silicates**	*Framework silicates*	Analcime		$Na_2AlSi_2O_6.H_2O$	1318-10-1		
22	3	3			**Silicates**	*Framework silicates*	Andesine		An40Ab60 – An30Ab70		Intermediate member of series with albite	
22	3	4			**Silicates**	*Framework silicates*	Anorthite		$KAlSi_3O_8$		End member of series with albite	
22	3	5			**Silicates**	*Framework silicates*	Anorthoclase		$(Na,K)AlSi_3O_8$		Common clay mineral; not currently recorded as a pigment	
22	3	6			**Silicates**	*Framework silicates*	Bytownite		$(Na,Si.Ca,Al)AlSi_2O_8$		Intermediate member of series with albite	
22	3	7			**Silicates**	*Framework silicates*	Gmelinite		$(Na_2,Ca)Al_2Si_4O_{12}·6H_2O$		Kakoulli (1997)	
22	3	8			**Silicates**	*Framework silicates*	Hackmanite		$Na_8Al_6Si_6O_{24}(Cl_2,S)$		Related mineral; not currently recorded as a pigment	
22	3	9			**Silicates**	*Framework silicates*	Sodalite		$Na_4Al_3Si_3O_{12}Cl$	1302-90-5	Related mineral not known as a pigment (base structure related to ultramarine)	
22	3	10	1		**Silicates**	*Framework silicates*	Ultramarine		$Na_8Al_6Si_6O_{24}$		Widely recognized; rev.: Plesters (1993)	
22	3	10	2		**Silicates**	*Framework silicates*	Lazurite		$Na_8Al_6Si_6O_{24}$		Widely recognized; rev.: Plesters (1993)	
22	3	11			**Silicates**	*Framework silicates*	Ultramarine red		$2Na_2Al_2Si_2O_6.Na_2S$	12769-96-9		
22	3	12			**Silicates**	*Framework silicates*	Hauyne		$(Na,Ca)_{4\text{-}8}Al_6Si_6(O,S)_{24}(SO_4,Cl)_{1\text{-}2}$		Derrick et al (1999) 134-8	
22	3	13			**Silicates**	*Framework silicates*	Heulandite		$(Na,Ca)_{2\text{-}3}Al_3(Al,Si)_2Si_{13})_{36}.12H_2O$	1318-63-4		
22	3	14			**Silicates**	*Framework silicates*	Labradorite		$(Ca,Na)(Si,Al)_4O_8$		Intermediate member of series with albite. Schroeder (1954) specifically as extender	
22	3	15			**Silicates**	*Framework silicates*	Laumontite		$CaAl_2Si_4O_{12}.4H_2O$			
22	3	16			**Silicates**	*Framework silicates*	Microcline		$KAlSi_3O_8$		Jercher et al (1998); Watchman et al (in press)	
22	3	17			**Silicates**	*Framework silicates*	Nepheline		$(Na,K)AlSiO_4$		As component of nepheline syenites (used as fillers and extenders)	
22	3	18			**Silicates**	*Framework silicates*	Oligoclase		An30Ab70 – An90Ab10		Intermediate member of series with albite	
22	3	19			**Silicates**	*Framework silicates*	Orthoclase		$KAlSi_3O_8$	12251-44-4	Related mineral	
22	3	20			**Silicates**	*Framework silicates*	Sanidine		$KAlSi_3O_8$		Present authors in pigments from Pompeii (unpublished)	
22	3	21			**Silicates**	*Framework silicates*	Stellerite		$Ca_2Al_4Si_{14}O_{36}·14H_2O$		Kakoulli (1997)	
22	3	22			**Silicates**	*Framework silicates*	Stilbite		$Ca_2NaAl_5Si_{13}O_{36}·16H_2O$		Min. lit. (as commonly forming solid solution with stellerite)	
22	3	23			**Silicates**	*Framework silicates*	Wairakite		$CaAl_2Si_4O_{12}·2H_2O$		Present authors in pigments from Pompeii (unpublished)	
22	4	1			**Silicates**	*Nesosilicates*	Ellestadite		$Ca_5(SiO_4,PO_4,SO_4)_3(F,OH,Cl)$			
22	4	2			**Silicates**	*Nesosilicates*	Lead-ellestadite		$Pb_5(SiO_4,PO_4,SO_4)_3(F,OH,Cl)$		Corbeil et al (1996)	See also: Ellestadite
22	4	3			**Silicates**	*Nesosilicates*	Forsterite		Mg_2SiO_4	15118-03-3	Plesters (1993) 49 as impurity with lazurite	
22	4	4			**Silicates**	*Nesosilicates*	Olivine		$(Mg,Fe)SiO_4$		Related mineral	
22	5	1	1		**Silicates**	*Orthosilicates*	Zirconium silicate		$ZrSiO_4$	10101-52-7	*Colour Index* (1971) 77995	
22	5	1	2		**Silicates**	*Orthosilicates*	Zircon		$ZrSiO_4$	14940-68-2	*Colour Index* (1971) 77995	
22	6	1			**Silicates**	*Ring silicates*	Chrysocolla		$(Cu,Al)_2H_2Si_20_5(OH)_4.xH_2O$		Spurrell (1895); Gettens (1938); Scott et al. (1998)	
22	6	2			**Silicates**	*Ring silicates*	Dioptase		$CuSiO_3.H_2O$	15606-25-4	Tubb (1987); Scott (2001)	
22	7	1	1		**Silicates**	*Sheet/ring silicates*	Barium copper silicate, effenbergerite type		$BaCuSi_4O_{10}$	16482-38-5	Fitzhugh & Zycherman (1983)	
22	7	1	2		**Silicates**	*Sheet/ring silicates*	Effenbergerite		$BaCuSi_4O_{10}$		Mineral analogue	
22	7	2			**Silicates**	*Sheet/ring silicates*	Barium copper silicate, 'purple' type		$BaCuSi_2O_6$		Fitzhugh & Zycherman (1992)	
22	7	3			**Silicates**	*Sheet/ring silicates*	Barium copper silicate		$BaCu_2Si_2O_7$		Finger et al. (1989); Wiedemann & Bayer (1997)	
22	7	4			**Silicates**	*Sheet/ring silicates*	Barium copper silicate		$Ba_2CuSi_2O_7$		Finger et al. (1989); Wiedemann & Bayer (1997)	
22	7	5	1		**Silicates**	*Sheet/ring silicates*	Calcium copper silicate, cuprorivaite type		$CaCuSi_4O_{10}$	10279-60-4	Widely recognized. Revs.: Riederer (1997)	
22	7	5	2		**Silicates**	*Sheet/ring silicates*	Cuprorivaite		$CaCuSi_4O_{10}$		Mineral analogue	
22	8	1			**Silicates**	*Sheet silicates: Micas: Bioti*	Biotite		$K(Mg,Fe^{2+})_3(Al,Fe^{3+})Si_3O_{10}(OH,F)_2$		*Colour Index* (1971) 77019	
22	8	2			**Silicates**	*Sheet silicates: Micas: Bioti*	Phlogopite		$K[Mg_3(OH)_2Si_3AlO_{10}]$	61076-94-6	*Colour Index* (1971) 77019	
22	8	3	1	1	**Silicates**	*Sheet silicates: Micas: Muscovite*	Muscovite		$KAl_2(Si_3Al)O_{10}(OH,F)_2$	1318-94-1	*Colour Index* (1971) 77019; Watchman et al. (1993)	
22	8	3	1	2	**Silicates**	*Sheet silicates: Micas: Muscovite*	Muscovite, var. fuchsite		$KAl_2(AlSi_3)O_{10}(F,OH)_2$		Current availability from Kremer Pigmente	See: Muscovite
22	8	4			**Silicates**	*Sheet silicates: Micas: Lepidolite*	Lepidolite		$Kli_2Al(Al,Si)_3O_{10}(F,OH)_2$		*Colour Index* (1971) 77019	
22	8	5			**Silicates**	*Sheet silicates: Micas:*	Celadonite		$K(Mg,Fe^{2+})(Fe^{3+},Al)Si_4O_{10}(OH)$		Grissom (1986); Odin & Delamare (1986)	
22	8	6			**Silicates**	*Sheet silicates: Clays: Illites*	Illite		$(K,H)Al_2(Si, Al)_4O_{10}(OH)_{2\ x}H_2O$	12173-60-3	Couraud (1987); Watchman et al. (1993); Ford et al. (1994)	

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α	β	γ	δ	ε	GROUP	SUB-GROUP	CHEMICAL NAME	VARIANT FORM	CHEMICAL FORMULA	CAS Number	LITERATURE	Notes
22	8	7			**Silicates**	*Sheet silicates: Clays: Sepiolites*	Palygorskite		$(Mg,Al)_5(Si,Al)_8O_{20}(OH)_2.8H_2O$	12174-11-7	Gettens (1961) and others [as substrate for 'Maya blue']	Previously known as 'attapulgite'
22	8	8			**Silicates**	*Sheet silicates: Clays: Sepiolites*	Sepiolite		$Mg_4Si_6O_{15}(OH)_2{\cdot}6H_2O$	63800-37-3	Van Olphen (1966) and Littmann (1980) [as alternate substrate for 'Maya blue']	
22	8	9			**Silicates**	*Sheet silicates: Clays: Smectites*	Beidellite		$Na_{0.5}Al_2(Si_{3.5}Al_{0.5})O_{10}(OH)_2{\cdot}n(H_2O)$		As component of bentonite (Heaton (1928); Lawrence (1960); then min. lit.)	
22	8	10			**Silicates**	*Sheet silicates: Clays: Smectites*	Montmorillonite		$(Na,Ca)_{0.3}(Al,Mg)_2Si_4O_{10}(OH)_2{\cdot}n(H_2O)$	1318-93-0	As component of bentonite (Heaton (1928); Lawrence (1960); then min. lit.)	
22	8	11			**Silicates**	*Sheet silicates: Clays: Smectites*	Volkonskoite		$a_{0.3}(Cr^{3+},Mg,Fe^{3+})_2(Si,Al)_4O_{10}(OH)_2{\cdot}{}^{\cdot}H_2O)$		Available from Kremer Pigmente, 2001	
22	8	12			**Silicates**	*Sheet silicates: Clays: Vermiculites*	Vermiculite		$(Mg,Fe^{2+},Al)_3(Al,Si)_4O_{10}(OH)_2.4(H_2O)$	1318-00-9		
22	8	13			**Silicates**	*Sheet silicates: Clays: Kaolinite – Serpentine*	Kaolinite		$Al_4[Si_4O_{10}](OH)_8$	1318-74-7	Stos-Fertner et al. (1979); Watchman et al. (1993); Huxtable & Pickering (1979); Grissom (1986)	
22	8	14			**Silicates**	*Sheet silicates: Clays: Kaolinite – Serpentine*	Dickite		$Al_2Si_2O_5(OH)_4$	1318-45-2		
22	8	15			**Silicates**	*Sheet silicates: Clays: Kaolinite – Serpentine*	Halloysite		$Al_2Si_2O_5(OH)_4.2H_2O$	12068-50-7	Scott & Hyder (1993)	
22	8	16			**Silicates**	*Sheet silicates: Clays: Kaolinite – Serpentine*	Nacrite		$Al_2Si_2O_5(OH)_4$	12279-65-1	Related mineral	
22	8	17			**Silicates**	*Sheet silicates: Chlorite*	Prochlorite			1318-59-8		
22	8	18			**Silicates**	*Sheet silicates: Chlorite*	Clinochlore		$(Mg,Fe^{2+})_5Al(Si_3Al)O_{10}(OH)_8$			
22	8	19			**Silicates**	*Sheet silicates: Chlorite*	Penninite					
22	8	20			**Silicates**	*Sheet silicates: Serpentine*	Antigorite		$(Mg,Fe^{2+})_3Si_2O_5(OH)_4$	61076-98-0	Ford et al. (1994)	
22	8	21			**Silicates**	*Sheet silicates: Serpentine*	Lizardite		$Mg_3Si_2O_5(OH)_4$	12161-84-1		
22	8	22			**Silicates**	*Sheet silicates: Serpentine*	Orthochrysotile		$Mg_3Si_2O_5(OH)_4$	12001-29-5	Type of asbestos (e.g., Heaton (1928))	
22	8	23			**Silicates**	*Sheet silicates: Serpentine*	Parachrysotile		$Mg_3Si_2O_5(OH)_4$		Type of asbestos (e.g., Heaton (1928))	
22	8	24			**Silicates**	*Sheet silicates: Serpentine*	Clinochrysotile		$Mg_3Si_2O_5(OH)_4$		Type of asbestos (e.g., Heaton (1928))	
22	8	25			**Silicates**	*Sheet silicates: Anomolous sheet silicates sub-group*	Talc		$Mg_3Si_4O_{10}(OH)_2$	14807-96-6	*Colour Index* (1971) 77718	
22	8	26			**Silicates**	*Sheet silicates: Anomolous sheet silicates sub-group*	Pyrophyllite		$Al_2Si_4O_{10}(OH)_2$	12269-78-2	Patton (1973e)	
22	8	27			**Silicates**	*Sheet silicates: Anomolous sheet silicates sub-group*	Prehnite		$Ca_2Al_2Si_3O_{10}(OH)_2$			
22	9	1			**Silicates**	[Unknown structure]	Aerinite		$Ca_4(Al,Fe^{3+},Mg,Fe^{2+})_{10}Si_{12}O_{36}(CO_3)\cdot12H_2O$		Casas (1991)	
22	9	2			**Silicates**	[Unknown structure]	Lead oxide silicate		$PbSiO_3.3PbO$		Dunn (1973a) as coating on 'basic lead silico sulfate'	
22	9	3			**Silicates**	[Unknown structure]	Lead oxide silicate hydrate		$3PbO.2SiO_2.H_2O$		Dunn (1973a); Gellner et al (1934)	
22	9	4			**Silicates**	[Unknown structure]	Sodium aluminium silicate		$9Na_2O.67SiO_2.12Al_2O_3$		Patton (1973d) as 'sodium silico aluminate'	Formula is stated to be 'typical'
23	1	1			**Silver**	*Silver*	Silver		Ag	7440-22-4	[Known use as leaf]	
23	2				**Silver**	*Carbonates*						
23	3				**Silver**	*Cyanides*						
23	4	1			**Silver**	*Halides*	Silver chloride		$AgCl_2$	7783-90-6	Seccarroni (*pers. comm.*.) as 'silver white'	
23	5	1			**Silver**	*Nitrates*	Silver nitrate		$AgNO_3$	7761-88-8	Art of Drawing (1757); de Massoul (1797) [Uncertain]	
23	6				**Silver**	*Oxides & hydroxides*						
23	7				**Silver**	*Phosphates*						
23	8				**Silver**	*Sulfides*						
23	9	1			**Silver**	*Sulfates*	Silver sulfate		$AgSO_4$	10294-26-5	Art of Drawing (1757); de Massoul (1797) [Uncertain]	
23	10				**Silver**	*Organo-silver compounds*						
24	1	1			**Sodium**	*Sodium*						
24	2	1			**Sodium**	*Carbonates*	Sodium carbonate		Na_2CO_3			
24	2	2			**Sodium**	*Carbonates*	Sodium hydrogen carbonate		$NaHCO_3$			
24	2	3			**Sodium**	*Carbonates*	Sodium bicarbonate carbonate hydrate		$Na_3(HCO_3)(CO_3).2H_2O$			
24	2	4			**Sodium**	*Carbonates*	Trona		$Na_3(HCO_3)(CO_3).2H_2O$			
25	1				**Strontium**	*Strontium*						
25	2	1	1		**Strontium**	*Carbonates*	Strontium carbonate		$SrCO_3$			
25	2	1	2		**Strontium**	*Carbonates*	Strontianite		$SrCO_3$		Olsson et al. (2001); Matteini et al. (2002)	
25	3				**Strontium**	*Cyanides*						
25	4				**Strontium**	*Halides*						
25	5				**Strontium**	*Nitrates*						
25	6				**Strontium**	*Oxides & hydroxides*						
25	7	1	2		**Strontium**	*Phosphates*	Goyazite		$SrAl_3(PO_4)_2(OH)_5{\cdot}(H_2O)$		Huq et al. (2001)	
25	8				**Strontium**	*Sulfides*						
25	9	1			**Strontium**	*Sulfates*	Strontium sulfate		$SrSO_4$	7759-02-6	Zerr & Rübencamp (1908)	
25	9	2			**Strontium**	*Sulfates*	Celestite		$SrSO_4$	14291-02-2	Related mineral	
25	10				**Strontium**	*Organo-strontium compounds*						
26	1	1			**Sulfur**	*Elemental sulfur*	Sulfur, amorphous type		S(am)	7704-34-9	Fiedler & Bayard (1986), as component of early pale cadmium yellows	
26	1	2			**Sulfur**	*Elemental sulfur*	Sulfur, orthorhombic type		S_8	10544-50-0	Stodulski et al. (1984)	

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α	β	γ	δ	ε	GROUP	SUB-GROUP	CHEMICAL NAME	VARIANT FORM	CHEMICAL FORMULA	CAS Number	LITERATURE	Notes
27	1	1			**Tin**	*Tin*	Tin		Sn	7440-31-5	Duncan et al. (1990)	
27	2				**Tin**	*Carbonates*						
27	3				**Tin**	*Cyanides*						
27	4				**Tin**	*Halides*						
27	5	1			**Tin**	*Nitrates*	Tin nitrate, basic					
27	6	1	1		**Tin**	*Oxides & hydroxides*	Tin(II) oxide, romarchite type		SnO			
27	6	1	2		**Tin**	*Oxides & hydroxides*	Romarchite		SnO		Smith et al. (1989)	
27	6	2	1		**Tin**	*Oxides & hydroxides*	Tin(IV) oxide, cassiterite type		SnO_2	18282-10-5	*Colour Index* (1971) 77861/Pigment White 15	
27	6	2	2		**Tin**	*Oxides & hydroxides*	Cassiterite		SnO_2		*Colour Index* (1971) 77861/Pigment White 15	
27	6	3			**Tin**	*Oxides & hydroxides*	Tin(IV) oxide, hexagonal type		SnO_2		Related form	
27	6	4			**Tin**	*Oxides & hydroxides*	Tin(IV) oxide, orthorhombic type		SnO_2		Related form	
27	7				**Tin**	*Phosphates*						
27	8	1	1		**Tin**	*Sulfides*	Tin(II) sulfide		SnS	1314-95-0	Related form	
27	8	1	2		**Tin**	*Sulfides*	Herzenbergite		SnS		Related form	
27	8	2	1		**Tin**	*Sulfides*	Tin(II,IV) sulfide		β-Sn_2S_3		Related form	
27	8	2	2		**Tin**	*Sulfides*	Ottemannite		β-Sn_2S_3		Related form	
27	8	3	1		**Tin**	*Sulfides*	Tin(IV) sulfide		SnS_2	1315-01-1	Smith et al. (1981); Speleers (1999)	
27	8	3	2		**Tin**	*Sulfides*	Berndtite		SnS_2		Smith et al. (1981); Speleers (1999)	
27	9				**Tin**	*Sulfates*						
27	10				**Tin**	*Organo-tin compounds*						
28	1				**Titanium**	*Titanium*						
28	2				**Titanium**	*Carbonates*						
28	3				**Titanium**	*Cyanides*						
28	4				**Titanium**	*Halides*						
28	5				**Titanium**	*Nitrates*						
28	6	1	1		**Titanium**	*Oxides & hydroxides*	Titanium(IV) oxide, anatase type		TiO_2	13463-67-7	Widely recognized (rev.: Laver (1997))	
28	6	1	2		**Titanium**	*Oxides & hydroxides*	Anatase		TiO_2	1317-70-0	Watchman et al. (in press)	
28	6	2	1		**Titanium**	*Oxides & hydroxides*	Titanium(IV) oxide, brookite type		TiO_2		Related form	
28	6	2	2		**Titanium**	*Oxides & hydroxides*	Brookite		TiO_2	12188-41-9	Mineral analogue	
28	6	3	1		**Titanium**	*Oxides & hydroxides*	Titanium(IV) oxide, rutile type		TiO_2		Widely recognized (rev.: Laver (1997))	
28	6	3	2		**Titanium**	*Oxides & hydroxides*	Rutile		TiO_2	1317-80-2	Mineral analogue	
28	6	4			**Titanium**	*Oxides & hydroxides*	Potassium titanate		$(K_2O)_{1/x}(TiO_2)_4$		Riches (1973)	
28	6	5			**Titanium**	*Oxides & hydroxides*	Titanium barium oxide (‘barium titanate’)		$BaTiO_3$	12047-27-7	Laver (1997)	
28	6	6			**Titanium**	*Oxides & hydroxides*	Titanium barium nickel oxide		$2NiO.3BaO.17TiO_2$			
28	6	7			**Titanium**	*Oxides & hydroxides*	Titnium lead oxide (‘lead titanate’)		$PbTiO_3$	12060-00-3	*Colour Index* (1971) 77645/PY 47	
28	6	8			**Titanium**	*Oxides & hydroxides*	Titanium zinc oxide (‘zinc titanate’)		$ZnTiO_3$	12036-43-0	*Colour Index* (1971) 77980; Kim et al. (2001)	
28	6	9			**Titanium**	*Oxides & hydroxides*	Titanium zinc oxide		Zn_2TiO_4		Kim et al. (2001)	
28	6	10			**Titanium**	*Oxides & hydroxides*	Titanium zinc oxide		$Zn_2Ti_3O_8$		Kim et al. (2001)	
28	6	11			**Titanium**	*Oxides & hydroxides*	Titanium antimony chromium oxide		$(Ti_{0.90}Sb_{0.05}Cr_{0.05})O_2$	68186-90-3	*Colour Index* (1971) 77310	
28	6	12			**Titanium**	*Oxides & hydroxides*	Titanium antimony nickel oxide		$(Ti_{0.85}Sb_{0.10}Ni_{0.05})O_2$	8007-18-9	*Colour Index* (1971) 77788	
28	7				**Titanium**	*Phosphates*						
28	8				**Titanium**	*Sulfides*						
28	9				**Titanium**	*Sulfates*						
28	10				**Titanium**	*Organo-titanium compounds*	Titanium phthalate				Laver (1997)	
29	1				**Tungsten**	*Tungsten*						
29	2				**Tungsten**	*Carbonates*						
29	3				**Tungsten**	*Cyanides*						
29	4				**Tungsten**	*Halides*						
29	5				**Tungsten**	*Nitrates*						
29	6	1			**Tungsten**	*Oxides & hydroxides*	Tungsten hydroxide		WHO			
29	6	2			**Tungsten**	*Oxides & hydroxides*	Tungsten oxide		WO			
29	6	3			**Tungsten**	*Tungstates*	Barium tungstate		$BaWO_4$	7787-42-0	Salter (1869) 414-5	
29	6	4			**Tungsten**	*Tungstates*	Cadmium tungstate		$CdWO_4$	7790-85-4	*Colour Index* (1971) 77208	
29	6	5	1		**Tungsten**	*Tungstates*	Calcium tungstate		$CaWO_4$	7790-75-2	Zerr and Rübencamp (1908); *Colour Index* (1971) 77250	
29	6	5	2		**Tungsten**	*Tungstates*	Scheelite		$CaWO_4$	14913-80-5	Related mineral	
29	6	6			**Tungsten**	*Tungstates*	Cobalt tungstate		$CoWO_4$	10101-58-3	*Colour Index* (1971) 77376	
29	6	7	1		**Tungsten**	*Tungstates*	Lead tungstate, raspite type		$PbWO_4$	7759-01-5	Riffault et al. (1874)	
29	6	7	2		**Tungsten**	*Tungstates*	Raspite		$PbWO_4$	14567-59-0 or 15502-08-6	Related mineral	
29	6	8	1		**Tungsten**	*Tungstates*	Lead tungstate, stolzite type		$PbWO_4$		Related mineral	
29	6	8	2		**Tungsten**	*Tungstates*	Stolzite		$PbWO_4$		Related mineral	
29	7				**Tungsten**	*Phosphates*						
29	8				**Tungsten**	*Sulfides*						
29	9				**Tungsten**	*Sulfates*						
29	10				**Tungsten**	*Organo-tungsten compounds*						
30	1				**Uranium**	*Uranium*						
30	2				**Uranium**	*Carbonates*						
30	3				**Uranium**	*Cyanides*						

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α	β	γ	δ	ε	GROUP	SUB-GROUP	CHEMICAL NAME	VARIANT FORM	CHEMICAL FORMULA	CAS Number	LITERATURE	Notes
30	4				**Uranium**	*Halides*						
30	5				**Uranium**	*Nitrates*						
30	6	1			**Uranium**	*Oxides*	Uranium(IV) oxide		UO_2	1344-57-6		
30	6	2			**Uranium**	*Oxides*	Uranium(VI) oxide		UO_3	1344-58-7		
30	6	3			**Uranium**	*Oxides*	Uranium(IV,VI) oxide (Uranium uranate)		U_3O_8	1344-59-8		
30	6	4			**Uranium**	*Oxides*	Uranium peroxide		$(UO_2^{2+})(O_2^{2-})(H_2O)_2$			
30	6	5			**Uranium**	*Oxides with Group 2 elements (Sr, Ba)*	Barium uranium oxide		BaU_7O_2			
30	6	6			**Uranium**	*Oxides with Group 2 elements (Sr, Ba)*	Strontium uranium oxide		$SrUO_4$	14312-10-8		
30	7				**Uranium**	*Phosphates*						
30	8				**Uranium**	*Sulfides*						
30	9				**Uranium**	*Sulfates*						
30	10				**Uranium**	*Organo-uranium compounds*						
31	1				**Vanadium**	*Vanadium*						
31	2				**Vanadium**	*Carbonates*						
31	3				**Vanadium**	*Cyanides*						
31	4				**Vanadium**	*Halides*						
31	5				**Vanadium**	*Nitrates*						
31	6				**Vanadium**	*Oxides*						
31	6	1			**Vanadium**	*Oxides with Group 3-11 elements (Cu)*	Copper vanadate		CuV_2O_6		Nord & Tronner (1998)	
31	6	2	1		**Vanadium**	*Oxides with Group 14-15 elements (Pb)*	Lead chloride vanadate		$Pb_5(VO_4)_3Cl$	12157-94-7	Synthetic analogue	
31	6	2	2		**Vanadium**	*Oxides with Group 14-15 elements (Pb)*	Vanadinite		$Pb_5(VO_4)_3Cl$	1307-08-0	Rouveret & Walter (1998)	
31	7				**Vanadium**	*Phosphates*						
31	8				**Vanadium**	*Sulfides*						
31	9				**Vanadium**	*Sulfates*						
31	10				**Vanadium**	*Organo-vanadium compounds*						
32	1	1			**Zinc**	*Zinc*	Zinc		Zn	7440-66-6	Bieganska et al (1988); Buxbaum (1998) 209	Anticorrosive pigment
32	2	1	1		**Zinc**	*Carbonates*	Zinc carbonate		$ZnCO_3$	3486-35-9	*Colour Index* (1971) 77950	
32	2	1	2		**Zinc**	*Carbonates*	Smithsonite		$ZnCO_3$		Mineral analogue	
32	2	2	1		**Zinc**	*Carbonates*	Zinc carbonate hydroxide, hydrozincite type		$2ZnCO_3.3Zn(OH)_2$	12070-69-8	*Colour Index* (1971) 77951	
32	2	2	2		**Zinc**	*Carbonates*	Hydrozincite		$2ZnCO_3.3Zn(OH)_2$		Mineral analogue	
32	3				**Zinc**	*Cyanides*						
32	4				**Zinc**	*Halides*						
32	5				**Zinc**	*Nitrates*						
32	6	1	1	1	**Zinc**	*Oxides & hydroxides*	Zinc oxide	Acicular form	ZnO	1314-13-2	Widely recognized; rev.: Kühn (1986)	
32	6	1	1	2	**Zinc**	*Oxides & hydroxides*	Zinc oxide	Nodular form	ZnO	1314-13-2	Widely recognised; rev.: Kühn (1986)	
32	6	2			**Zinc**	*Oxides & hydroxides*	Zinc oxide hydrate		[---]		Toch (1916) as ‘Zinox’	Uncertain composition
32	6	3			**Zinc**	*Oxides & hydroxides*	Zincite		(Zn,Mn)O		Related mineral	
32	7	1			**Zinc**	*Phosphates*	Zinc phosphate		$Zn_2P_2O_7$	7779-90-0	*Colour Index* (1971) 77965	
32	7	2			**Zinc**	*Phosphates*	Zinc phosphate hydrate		$Zn_3(PO_4)_2.4H_2O$		*Colour Index* (1971) 77964/PW 32	
32	8	1	1		**Zinc**	*Sulfides*	Zinc sulfide		ZnS	1314-98-3	e.g., Heaton (1928)	
32	8	1	2		**Zinc**	*Sulfides*	Matraite		ZnS		Related mineral	
32	8	2			**Zinc**	*Sulfides*	Zinc sulfide hydrate		$ZnS.H_2O$		*Colour Index* (1971) 77975	
32	8	3			**Zinc**	*Sulfides*	Zinc oxide sulfide				*Colour Index* (1971) 77975 as ‘Griffith's zinc white’; also Bersch (1901) ?	
32	8	4			**Zinc**	*Sulfides*	Sphalerite		ZnFeS	12169-28-7	Related mineral	
32	9	1			**Zinc**	*Sulfates*	Zinc sulfate		$ZnSO_4$	7733-02-0	Zerr & Rübencamp (1908)	
32	10				**Zinc**	*Organo-zinc compounds*						
33	1				**Zirconium**	*Zirconium*						
33	2				**Zirconium**	*Carbonates*						
33	3				**Zirconium**	*Cyanides*						
33	4				**Zirconium**	*Halides*						
33	5				**Zirconium**	*Nitrates*						
33	6	1	1		**Zirconium**	*Oxides & hydroxides*	Zirconium oxide, arkelite type		ZrO_2		*Colour Index* (1971) 77990/PW 12; Blumenthal & Jacobs (1973); Brochwicz et al (1993)	
33	6	1	2		**Zirconium**	*Oxides & hydroxides*	Arkelite		ZrO_2		Related mineral	
33	6	2	1		**Zirconium**	*Oxides & hydroxides*	Zirconium oxide, baddeleyite type		ZrO_2		*Colour Index* (1971) 77990/PW 12; Blumenthal & Jacobs (1973)	Common modern pigmentary form
33	6	2	2		**Zirconium**	*Oxides & hydroxides*	Baddeleyite		ZrO_2		Related mineral	
33	7				**Zirconium**	*Phosphates*						
33	8				**Zirconium**	*Sulfides*						
33	9				**Zirconium**	*Sulfates*						
33	10				**Zirconium**	*Organo-zirconium compounds*						

α	β	γ	δ	ε	GROUP	SUB-GROUP	CHEMICAL NAME	VARIANT FORM	CHEMICAL FORMULA	CAS Number	LITERATURE	Notes
34	1	1	1		**Carbon**[7]	*Crystalline carbons*	Carbon, graphite type		C		Winter (1983)	
34	1	1	2		**Carbon**	*Crystalline carbons*	Graphite		C	7782-42-5	Winter (1983); Hsu Wei-yeh et al. (1983)	
34	1	1	3		**Carbon**	*Crystalline carbons*	Graphite, disordered type		C		Winter (1983)	
34	1	1	4		**Carbon**	*Crystalline carbons*	Chaoite		C		Winter (1983)	
34	1	1	5		**Carbon**	*Crystalline carbons*	Lonsdaleite		C		Winter (1983)	
34	1	2	1		**Carbon**	*Fullerenes*	Fullerene	Synthesised forms	C_{60} & C_{70}		Not currently known	
34	1	2	2	1	**Carbon**	*Fullerenes*	Fullerene	From shungite	C_{60} & C_{70}			Shungite, which is rich in fullerenes, currently supplied as a pigment
35	1	1			**Alkaloids**							
36	1	1			**Azo**[8]	*Monoazo pigments*	*et seq.* by CI number					
36	2	1			**Azo**	*Disazo pigments*	*et seq.* by CI number					
36	3	1			**Azo**	*β-Naphthol pigments*	*et seq.* by CI number					
36	4	1			**Azo**	*Naphthol AS pigments*	*et seq.* by CI number					
36	5	1			**Azo**	*Benzimidazolone pigments*	*et seq.* by CI number					
36	6	1			**Azo**	*Disazo condensation pigments*	*et seq.* by CI number					
36	7	1			**Azo**	*Metal complex pigments*	*et seq.* by CI number					
36	8	1			**Azo**	*Isoindolinone and Isoindoline pigments*	*et seq.* by CI number					
37	1	1			**Basic**	*Berberins*	Berberin	From *Berberis* spp.			Tingry (1830)	'Berberis' for a 'brownish Dutch pink'
38	1	1			**Benzophenone**							
39	1	1			**Betalain**							
40	1	1	2		**Carotinoid**	*Carotenes*	β-Carotene	From *Cuscuta* spp.			Wallert (1995c)	
40	2	1	2		**Carotinoid**	*Bixins*	Bixin	From *Bixa orellana* L.			Field (1835) 120; Salter (1869) 256	'Annatto'
40	3	1			**Carotinoid**	*Crocins*	Crocin				Related compound	
40	3	2	2		**Carotinoid**	*Crocins*	Crocetin	From *Crocus sativus*			Strasburg MS (1966)	'Saffron'
41	1	1			**Diaryl**	*Curcumins*	Curcumin	From *Curcuma longa* L.			Watin (1785) 26-7; Osborn (1845) 52; Lee et al. (1985)	'Turmeric'
41	1	2			**Diaryl**	*Curcumins*	Dimethoxycurcumin				Related compound (Schweppe (1992))	
41	1	3			**Diaryl**	*Curcumins*	Bisdimethoxycurcumin				Related compound (Schweppe (1992))	
42	1	1			**Flavonoid**[9]	*Flavones*[10]	Luteolin	From *Reseda luteola* L.			Widely recognized; e.g., see: Osborn (1845) 49	'Weld'
42	2	1			**Flavonoid**	*Flavonols*[11]	Catechin					
42	2	2			**Flavonoid**	*Flavonols*	Epichatechin					
42	2	3			**Flavonoid**	*Flavonols*	Rhamnetin	From *Rhamnus* spp.				
42	2	4			**Flavonoid**	*Flavonols*	Quercetin					
42	3	1			**Flavonoid**	*C-Glycosylflavones*						
42	4	1			**Flavonoid**	*Biflavonyls*						
42	5	1			**Flavonoid**	*Anthocyanins*						
42	6	1			**Flavonoid**	*Chalcones*						
42	7	1			**Flavonoid**	*Dihydrochalcones*						
42	8	1			**Flavonoid**	*Aurones*						
42	9	1	2		**Flavonoid**	*Flavanones*	Pinocembrin	From *Xanthorrhoea* spp.				NB: Pinocembrin is also found in honey
42	10	1	2		**Flavonoid**	*Dihydroflavanols*	Aromadendrin	From *Acacia catechu* (L.f.) Willd. and other *A.* spp.			Salter (1869) 354-5 as 'Catechu brown'	'Catechu'
42	11	1			**Flavonoid**	*Flavans/Proanthocyanins*						
42	12	1			**Flavonoid**	*Isoflavonoids/Neoflavonoids*	Brazilin					
42	12	2			**Flavonoid**	*Isoflavonoids/Neoflavonoids*	Brazilein					
42	12	3			**Flavonoid**	*Isoflavonoids/Neoflavonoids*	Haematoxylin					
42	12	4			**Flavonoid**	*Isoflavonoids/Neoflavonoids*	Haematein					
43	1	1			**Hexacyanoferrate(II)**	*Hexacyanoferrate(II) pigments with Fe(III) and M(I) ions (Na, K, NH_4)*	Iron(III) hexacyanoferrate(II)		$Fe_4[Fe(CN)_6]_3$		Berrie (1997)	Traditional formulation, probably inaccurate representation
43	1	2			**Hexacyanoferrate(II)**	*Hexacyanoferrate(II) pigments with Fe(III) and*	Ammonium iron hexacyanoferrate(II)		$(NH_4)Fe^{III}[Fe^{II}(CN)_6].nH_2O$, n=14-16	25869-00-5	Assumed modification in 'Monthier's blue'	Of dubious merit. Analytical studies suggest no such substitution occurs.

[7] Carbon arrangement follows that given in: Winter, J. "The characterization of pigments based on carbon" *Studies in Conservation* **28** (1983) 49-66, with modifications. Carbon-based blacks are listed separately in section B.

[8] Azo arrangement follows that given in the *Colour Index* (1971) and Herbst, Willy and Hunger, Klaus *Industrial organic pigments: production, properties, applications* 2nd ed., VCH, Weinheim (1997)

[9] Flavonoid arrangement follows that given in: Harborne, J.B. and Baxter, H. (eds.) *The Handbook of Natural Flavonoids*, 2 Vols., John Wiley & Sons, Chichester, UK (1999)

[10] This sub-group also includes the flavone *O*-glycosides.

[11] This sub-group also includes the flavonol *O*-glycosides.

α	β	γ	δ	ε	GROUP	SUB-GROUP	CHEMICAL NAME	VARIANT FORM	CHEMICAL FORMULA	CAS Number	LITERATURE	Notes
						M(I) ions (Na, K, NH_4)						
43	1	3			**Hexacyanoferrate(II)**	*Hexacyanoferrate(II) pigments with Fe(III) and M(I) ions (Na, K, NH_4)*	Potassium iron hexacyanoferrate(II)		$KFe^{III}[Fe^{II}(CN)_6].nH_2O$, n=14-16		Berrie (1997)	Of dubious merit. Analytical studies suggest no such substitution occurs.
43	1	4			**Hexacyanoferrate(II)**	*Hexacyanoferrate(II) pigments with Fe(III) and M(I) ions (Na, K, NH_4)*	Sodium iron hexacyanoferrate(II)		$NaFe^{III}[Fe^{II}(CN)_6].nH_2O$, n=14-16		Berrie (1997)	Of dubious merit. Analytical studies suggest no such substitution occurs.
43	2	1			**Hexacyanoferrate(II)**	*Hexacyanoferrate(II) pigments with Group 3-12 ions (including Co, Cu, Zn)*	Cobalt hexacyanoferrate(II)				Salter (1869) as 'Cobalt Prussian blue'	
43	2	2			**Hexacyanoferrate(II)**	*Hexacyanoferrate(II) pigments with Group 3-12 ions (including Co, Cu, Zn)*	Dicopper hexacyanoferrate(II) hydrate		$Cu_2Fe(CN)_6.xH_2O$		Bersch (1901) 280 as 'Hatchett brown'; *Colour Index* (1971) CI 77430/Pigment Brown 9	
43	2	3			**Hexacyanoferrate(II)**	*Hexacyanoferrate(II) pigments with Group 3-12 ions (including Co, Cu, Zn)*	Copper dipotassium hexacyanoferrate(II)		$CuK_2Fe(CN)_6$		Bersch (1901) 280 as 'Hatchett brown'; *Colour Index* (1971) CI 77430/Pigment Brown 9	
43	2	4			**Hexacyanoferrate(II)**	*Hexacyanoferrate(II) pigments with Group 3-12 ions (including Co, Cu, Zn)*	Titanium hexacyanoferrate(II)				Salter (1869) 290; Riffault et al. (1874); Terry (1893) 135; Laver (1997)	
43	2	5			**Hexacyanoferrate(II)**	*Hexacyanoferrate(II) pigments with Group 3-12 ions (including Co, Cu, Zn)*	Tungsten tin hexacyanoferrate(II)(?)				*Colour Index* (1971) 77515	
43	2	6			**Hexacyanoferrate(II)**	*Hexacyanoferrate(II) pigments with Group 3-12 ions (including Co, Cu, Zn)*	Vanadium hexacyanoferrate(II)				Salter (1869) 291 as 'vanadium green'	
43	2	7			**Hexacyanoferrate(II)**	*Hexacyanoferrate(II) pigments with Group 3-12 ions (including Co, Cu, Zn)*	Zinc hexacyanoferrate(II)				Terry (1893) 137 as 'zinc green'; *Colour Index* (1971) 77530	
43	3	1			**Hexacyanoferrate(II)**	*Hexacyanoferrate(II) pigments with Group 15 ions (including Sb)*	Antimony hexacyanoferrate(II)				Bersch (1901); *Colour Index* (77510)	
44	1	1	1		**Indigoid**	*Base compounds*	Indigo	Synthetic		482-89-3	Widely recognised	
44	1	1	2	1	**Indigoid**	*Base compounds*	Indigo	From *Indigofera tinctoria* L.			Widely recognised	
44	1	1	2	2	**Indigoid**	*Base compounds*	Indigo	From *Isatis tinctoria* L.			Widely recognised	
44	1	1	3		**Indigoid**	*Base compounds*	Indigo	From genetically modified bacteria (*Pseudomonas* spp. & *Escheria coli*)				
44	1	2			**Indigoid**	*Base compounds*	Indirubin			479-41-4		
44	2	1			**Indigoid**	*Halogenated compounds*[12]	6-Bromoindigo				Cooksey (2001)	
44	2	2			**Indigoid**	*Halogenated compounds*	6,6'-Dibromoindigo				Cooksey (2001)	
44	2	3			**Indigoid**	*Halogenated compounds*	6,6'-Dibromoindirubin				Cooksey (2001)	
44	2	4			**Indigoid**	*Halogenated compounds*	6-Bromoisatin				Cooksey (2001)	
44	3	1			**Indigoid**	*Sulfonated compounds*	Disodium 3,3'-dioxo-[$\Delta^{2,2'}$-biindoline]-5,5'-disulfonate			860-22-0	Balfour-Paul (1998)	'Indigo carmine'
44	3	2			**Indigoid**	*Sulfonated compounds*	Disodium 3,3'-dioxo-[$\Delta^{2,2'}$-biindoline]-5,7'-disulfonate				Balfour-Paul (1998)	'Indigo carmine'
44	4	1			**Indigoid**	*Thioindigoid compounds*	Thioindigo				Herbst & Hunger (1997)	
44	4	2			**Indigoid**	*Thioindigoid compounds*	4,4',7,7'-Tetrachlorothioindigo				Herbst & Hunger (1997)	CI Pigment Red 88
44	4	3			**Indigoid**	*Thioindigoid compounds*	4,4'-Dimethyl-6,6'-dichlorothioindigo				Herbst & Hunger (1997)	CI Pigment Red 181
45	1	1			**Orceins**	*Orcein*	α-amino-orcein				Harley (1982) as 'litmus', then chem.. lit. (Schweppe (1992))	Orcein is a composite; CAS # 1400-62-0
45	1	2			**Orceins**	*Orcein*	α-hydroxy-orcein				Harley (1982) as 'litmus', then chem.. lit. (Schweppe (1992))	
45	1	3			**Orceins**	*Orcein*	β-amino-orcein				Harley (1982) as 'litmus', then chem.. lit. (Schweppe (1992))	
45	1	4			**Orceins**	*Orcein*	β-hydroxy-orcein				Harley (1982) as 'litmus', then chem.. lit. (Schweppe (1992))	
45	1	5			**Orceins**	*Orcein*	β-amino-orceinimine				Harley (1982) as 'litmus', then chem.. lit. (Schweppe (1992))	
45	1	6			**Orceins**	*Orcein*	γ-amino-orcein				Harley (1982) as 'litmus', then chem.. lit. (Schweppe (1992))	
45	1	7			**Orceins**	*Orcein*	γ-hydroxy-orcein				Harley (1982) as 'litmus', then chem.. lit. (Schweppe (1992))	
45	1	8			**Orceins**	*Orcein*	γ- amino-orceinimine				Harley (1982) as 'litmus', then chem.. lit. (Schweppe (1992))	
46	1	1			**Porphyrins**	*Chlorophylls*	Chlorophyll a			1406-65-1	Mills & White (1994) 146 as major component of 'sap green', then chem.. lit.	

[12] For various other precursor or transient brominated compounds that occur in Tyrian purple, see Cooksey (2001)

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α	β	γ	δ	ε	GROUP	SUB-GROUP	CHEMICAL NAME	VARIANT FORM	CHEMICAL FORMULA	CAS Number	LITERATURE	Notes
46	1	2			**Porphyrins**	*Chlorophylls*	Chlorophyll b			1406-65-1	Mills & White (1994) 146 as major component of 'sap green', then chem.. lit.	
46	1	3			**Porphyrins**	*Chlorophylls*	Chlorophyll c			1406-65-1	Mills & White (1994) 146 as major component of 'sap green', then chem.. lit.	
46	2	1			**Porphyrins**	*Hemoglobins*	Hemoglobin			9008-02-0	cf. Bristow (1996) 232, n.13, then chem.. lit.	
46	2	2			**Porphyrins**	*Hemoglobins*	Heme				cf. Bristow (1996) 232, n.13, then chem.. lit.	
46	2	3			**Porphyrins**	*Hemoglobins*	Haemin			16009-13-5	cf. Bristow (1996) 232, n.13, then chem.. lit.	
46	2	4			**Porphyrins**	*Hemoglobins*	Bilirubin[13]			635-65-4	Thompson (1956) as 'Bile yellow' (?) then biochem.	Found in bile
46	2	5			**Porphyrins**	*Hemoglobins*	Biliverdin			114-25-0	Thompson (1956) as 'Bile yellow' (?) then biochem.	Found in bile
46	3	1			**Porphyrins**	*Phthalocyanines*[14]	Phthalocyanine			574-93-6		
46	3	2			**Porphyrins**	*Phthalocyanines*	Copper phthalocyanine			147-14-8		
46	3	3			**Porphyrins**	*Phthalocyanines*	Polychloro copper phthalocyanine					
46	3	4			**Porphyrins**	*Phthalocyanines*	Polychloro polybromo copper phthalocyanine					
47	1	1			**Quinones**	*Anthraquinones*	Alizarin			72-48-0	Schweppe & Winter (1997)	
47	1	2			**Quinones**	*Anthraquinones*	Purpurin			81-54-9	Schweppe & Winter (1997)	
47	1	3			**Quinones**	*Anthraquinones*	Pseudopurpurin				Schweppe & Winter (1997)	
47	1	4			**Quinones**	*Anthraquinones*	Rubiadin				Schweppe & Winter (1997)	
47	1	5			**Quinones**	*Anthraquinones*	Munjistin				Schweppe & Winter (1997)	
47	1	6			**Quinones**	*Anthraquinones*	Morindone				Schweppe & Winter (1997)	
47	1	7			**Quinones**	*Anthraquinones*	Xanthopurpurin				Schweppe & Winter (1997)	
47	1	8			**Quinones**	*Anthraquinones*	Rubiadin-1-methyl ether				Schweppe & Winter (1997)	
47	1	9			**Quinones**	*Anthraquinones*	Hystazarin-3-methyl ether				Schweppe & Winter (1997)	
47	1	10			**Quinones**	*Anthraquinones*	Anthragallol			602-64-2	Schweppe & Winter (1997)	
47	1	11			**Quinones**	*Anthraquinones*	Anthragallol-2-methyl ether				Schweppe & Winter (1997)	
47	1	12			**Quinones**	*Anthraquinones*	Anthragallol-1,2-dimethyl ether				Schweppe & Winter (1997)	
47	1	13			**Quinones**	*Anthraquinones*	Anthragallol-1,3-dimethyl ether				Schweppe & Winter (1997)	
47	1	14			**Quinones**	*Anthraquinones*	Soranjidiol				Schweppe & Winter (1997)	
47	1	15			**Quinones**	*Anthraquinones*	6-Methylxanthopurpurin				Schweppe & Winter (1997)	
47	1	16			**Quinones**	*Anthraquinones*	Lucidin				Schweppe & Winter (1997)	
47	1	17			**Quinones**	*Anthraquinones*	Ibericin				Schweppe & Winter (1997)	
47	1	18			**Quinones**	*Anthraquinones*	2-Hydroxyanthraquinone				Schweppe & Winter (1997)	
47	1	19			**Quinones**	*Anthraquinones*	1-Hydroxy-2-methylanthraquinone				Schweppe & Winter (1997)	
47	1	20			**Quinones**	*Anthraquinones*	3-Hydroxy-2-methylanthraquinone				Schweppe & Winter (1997)	
47	1	21			**Quinones**	*Anthraquinones*	Alizarin-1-methyl ether				Schweppe & Winter (1997)	
47	1	22			**Quinones**	*Anthraquinones*	Xanthopurpurin-1-methyl ether				Schweppe & Winter (1997)	
47	1	23			**Quinones**	*Anthraquinones*	Xanthopurpurin-3-methyl ether				Schweppe & Winter (1997)	
47	1	24			**Quinones**	*Anthraquinones*	2-Benzylxanthopurpurin				Schweppe & Winter (1997)	
47	1	25			**Quinones**	*Anthraquinones*	6-Methylquinizarin				Schweppe & Winter (1997)	
47	1	26			**Quinones**	*Anthraquinones*	Damnacanthol				Schweppe & Winter (1997)	
47	1	27			**Quinones**	*Anthraquinones*	Damnacanthal				Schweppe & Winter (1997)	
47	1	28			**Quinones**	*Anthraquinones*	Nordamnacanthal				Schweppe & Winter (1997)	
47	1	29			**Quinones**	*Anthraquinones*	Physcion				Schweppe & Winter (1997)	
47	1	30	2		**Quinones**	*Anthraquinones*	Aloe-emodin	From *Aloe* spp.			Widely recognized; e.g., see: Mills & White (1987)	
47	1	31			**Quinones**	*Anthraquinones*	Chrysophanol					Occurs in various species used for pigment production, including *Aloe* and *Cassia*, and probably also *Rheum*
47	1	32			**Quinones**	*Anthraquinones*	Emodin					
47	1	33			**Quinones**	*Anthraquinones*	Rhein					
47	1	34			**Quinones**	*Anthraquinones*	Rheidin					
47	1	35			**Quinones**	*Anthraquinones*	Sennoside A-D					
47	1	36			**Quinones**	*Anthraquinones*	Kermesic acid					'Kermes'
47	1	37			**Quinones**	*Anthraquinones*	Flavokermesic acid					'Kermes'
47	1	38			**Quinones**	*Anthraquinones*	Laccaic acid A					
47	1	39			**Quinones**	*Anthraquinones*	Laccaic acid B					
47	1	40			**Quinones**	*Anthraquinones*	Laccaic acid C					
47	1	41			**Quinones**	*Anthraquinones*	Laccaic acid D					
47	1	42			**Quinones**	*Anthraquinones*	Laccaic acid E					
47	1	43			**Quinones**	*Anthraquinones*	Laccaic acid F					Only known from Thai stick lac (White & Kirby, 2001)
47	1	44			**Quinones**	*Anthraquinones*	Erythrolaccin					
47	1	45			**Quinones**	*Anthraquinones*	Isoerythrolaccin					
47	1	46			**Quinones**	*Anthraquinones*	Deoxyerythrolaccin					
47	2	1			**Quinones**	*Anthraquinones:*						

[13] Bilirubin and biliverdin are naturally occurring tetrapyrroles, but classed here with hemoglobin, of which they are decomposition products.
[14] As a result of the structure of phthalocyanine many substitutions can be achieved and at least 70 metal phthalocyanines have been prepared; further, as a result of the 16 reactive sites on the four benzene units, over 5000 further compounds have also been made. Polymorphism has been widely recognised in these compounds with the discovery of various crystal forms of copper and other metal phthalocyanines; however, few of these have found substantial use as pigments. Only the principal pigmentary forms are listed here.

α	β	γ	δ	ε	GROUP	SUB-GROUP	CHEMICAL NAME	VARIANT FORM	CHEMICAL FORMULA	CAS Number	LITERATURE	Notes
						Anthanthrones						
47	3	1			**Quinones**	*Anthraquinones: Anthrapyrimidines*						
47	4	1			**Quinones**	*Anthraquinones: Flavanthrones*						
47	5	1			**Quinones**	*Anthraquinones: Indanthrones*						
47	6	1			**Quinones**	*Anthraquinones: Pyranthrones*						
47	7	1	2		**Quinones**	*Benzoquinones*	Carthamin	From *Carthamus tinctorius* L.			Watin (1785); Harley (1982)	‘Safflower’
47	8	1	2		**Quinones**	*Naphthoquinones*	Alkannin	From *Alkanna tinctoria* Tausch.			Tingry (1830) as alkanet, then chem. lit.	‘Alkanet’
47	8	2	2		**Quinones**	*Naphthoquinones*	Alkannan	From *Alkanna tinctoria* Tausch.			Tingry (1830) as alkanet, then chem. lit.	
47	8	3			**Quinones**	*Naphthoquinones*	Shikonin					
47	8	4	2		**Quinones**	*Naphthoquinones*	Juglone	From *Juglans* spp.		481-39-0		
48	1	1	2		**Xanthones**	*Xanthones*	Carajurin	From *Bignonia chica* Humb. et Bonpl.			Salter (1869) as ‘chica’; *Colour Index* (1971) Natural Orange 5	
48	1	2			**Xanthones**	*Xanthones*	Euxanthone				Related compound (Indian yellow)	
48	1	3			**Xanthones**	*Xanthones*	Euxanthic acid				Related compound (Indian yellow)	
48	1	4			**Xanthones**	*Xanthones*	Euxanthic acid, calcium salt				Widely recognized as ‘Indian yellow’; rev.: Baer et al. (1986)	
48	1	5			**Xanthones**	*Xanthones*	Euxanthic acid, magnesium salt				Widely recognized as ‘Indian yellow’; rev.: Baer et al. (1986)	
48	1	6	2		**Xanthones**	*Xanthones*	Dracorubin	From *Daemonorops* spp.				‘Dragon’s blood’. Group assignment according to Schweppe (1992)
48	1	7	2		**Xanthones**	*Xanthones*	Dracorhodin	From *Daemonorops* spp.				‘Dragon’s blood’. Group assignment according to Schweppe (1992)
48	1	8	2		**Xanthones**	*Xanthones*	Gentisin	From *Gentiana lutea* L.			Salter (1869) 180; Schweppe (1992)	‘Wongshy red’ (obsc.)
48	2	1	2		**Xanthones**	*Hydroxanthones*	Gambogic acid	From *Garcinia* spp.			Winter (1997)	Gamboge constituent
48	2	2	2		**Xanthones**	*Hydroxanthones*	Isogambogic acid	From *Garcinia* spp.			Winter (1997)	Gamboge constituent
48	2	3	2		**Xanthones**	*Hydroxanthones*	Morellic acid	From *Garcinia* spp.			Winter (1997)	Gamboge constituent
48	2	4	2		**Xanthones**	*Hydroxanthones*	Isomorellic acid	From *Garcinia* spp.			Winter (1997)	Gamboge constituent
48	2	5	2		**Xanthones**	*Hydroxanthones*	Morellin	From *Garcinia* spp.			Winter (1997)	Gamboge constituent
48	2	6	2		**Xanthones**	*Hydroxanthones*	Morellinol	From *Garcinia* spp.			Winter (1997)	Gamboge constituent
48	2	7	2		**Xanthones**	*Hydroxanthones*	Isomorellinol	From *Garcinia* spp.			Winter (1997)	Gamboge constituent
48	2	8	2		**Xanthones**	*Hydroxanthones*	Desoxymorellinol	From *Garcinia* spp.			Winter (1997)	Gamboge constituent
48	2	9	2		**Xanthones**	*Hydroxanthones*	Dihydroisomorellin	From *Garcinia* spp.			Winter (1997)	Gamboge constituent
48	2	10	2		**Xanthones**	*Hydroxanthones*	Neogambogic acid	From *Garcinia* spp.			Winter (1997)	Gamboge constituent

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B: COMMON NATURAL ORGANIC COMPOSITES

B.I. DYES

GENUS/SPECIES	FAMILY	TRIVIAL DYE NAME	DYE COMPONENTS[15]	LITERATURE	NOTES
PLANTS:[16]					
***Acacia* spp.** *A. catechu* (L.f.) Willd.	Leguminosae	Catechu (tannin)	**Catechin** [Epichatechin; Quercetin]	Salter (1869) as 'Catechu brown'	Salter also describes speculative pigments formed with metal salts
***Aesculus* spp.** *A. hippocastanum* L.	Hippocastanaceae	Chestnut brown		Salter (1869) as 'Hypocastanum' and 'Chestnut brown'	
***Alkanna* spp.** *A. tinctoria* Tausch.; *A. lehmannii* Tineo	Boraginaceae	Alkanet	**Alkannin**; **Alkannan**	Papageorgiou et al (1999)	
***Aloe* spp.** *A. barbadensis* Miller; *A. epatia*; *A. ferox*; *A. perryi*	Liliaceae	Aloe	**Aloe-emodin**; **Chrysophanol**		
***Berberis* spp.** *B. vulgaris* L. (and numerous others)	Berberidaceae	Berberis	**Berberine**; **Oxyacanthine**; Magnoflorine; Berberrubine; Berbamine; Jatrorrhizine; Columbamine; Palmatine; Isotetrandine	Boyle (1731) cf. Harley (1982) 118	
***Bignonia* spp.** *B. chica* Humb. et Bonpl.	Bignoniaceae	'Chica' or 'Chica Marrone'	**Carajurin**	Salter (1869)	
***Bixa* spp.** *B. orellana* L.	Bixaceae	Annatto	**Bixin**; Crocetin	Dossie (1758); Harley (1982) 118	
***Caesalpinia* spp.** *C. bonduc* (L.) Roxb.; *C. crista* L.; *C. echinata* Lam.; *C. japonica* Sieb. & Zucc.; *C. sappan* L.; *C. violacea* (Miller) Standley	Leguminosae	Brazilwood; Limawood; Sappan wood; Pernambuco wood; Peachwood	**Brasilein**	Widely recognised	*C. violacea* was formerly *C. brasiliensis* L.
***Carthamus* spp.** *C. tinctorius* L.	Compositae	Safflower	**Carthamin**	Harley (1982) 146-147	
***Cassia* spp.** *C. angustifolia* Vahl.; *C. auriculata* L.; *C. fistula* L.; *C. senna* L.; *C. tora* L.	Leguminosae	Cassia	**Aloe-emodin**; **chrysophanol**; **rhein**; **rheidin**; **sennoside A-D**	Salter (1869)	
***Centaurea* spp.** *C. cyanus* L.	Compositae	Cornflower blue	Apigenin (glucoside); Isoswertisin; Naringin; Cyanidin; Pelargonidin; Succinylcyanin	Harley (1982) 65-66	
***Chrozophora* spp.** *C. tinctoria* (L.) A. Juss.	Euphorbiaceae	Turnsole		Turner (1998) from Alcherius/Lebegue (Merrifield (1849); Harley (1982) 61-63	Syn.: *Croton tinctorium* L.
***Cichorium* spp.** *C. intybus* L.	Compositae	Chicory brown	Cyanidin and Delphinidin malonylglucosides *C. endivia* also contains Kaempferol	Salter (1869)	Probable modern use as a wood stain. Used after roasting of the root.
***Commelina* spp.** *C. communis* L.	Commelinaceae	Dayflower	**Commelinin**; Flavocommelin; Swertisin; Awobanin; Flavocommelitin	Shimoyama et al (1995); used in *Ukiyo-e* prints	
***Coprosma* spp.** *C. lucida* Forst.; *C. acerosa* Cunn.	Rubiaceae	Madder	**Lucidin**; **Anthragallol-2-methyl ether**; Anthragallol-1,2-dimethyl ether; Rubiadin; Soranjidiol; Anthragallol; 3-Hydroxy-2-methylanthraquinone; Rubiadin-1-methyl ether	Schweppe & Winter (1997)	
***Cotinus* spp.** *C. coggyria* Scop.	Anacardiaceae	'Young fustic'	**Fisetin** [Sulfuretin (spp.), Cyanidin; Delphinidin; Petunidin glucosides; Idaein]		
***Crocus* spp.** *C. sativus* L.	Iridaceae	Saffron	**Crocetin**	Harley (1982) 104	
***Croton* spp.** *C. aromaticus*; *C. draco*; *C. gossypiifolius*	Euphorbiaceae	Dragon's blood		Edwards et al. (1997); Pearson & Prendergast (2001)	
***Curcuma* spp.** *C. longa* L.; *C. zedoaria* (Christm.) Roscoe	Zingiberaceae	Turmeric	**Curcumin**; **Dimethoxycurcumin**; **Bisdimethoxycurcumin**	Dossie (1758); Harley (1982) 118; Lee et al (1985)	
***Cuscuta* spp.** *C. tinctoria* Mart.; *C. americana* Linn.; *C. odontolepis* Engelmann	Convolvulaceae (Cuscutaceae)	Cuscuta	**β- and γ-Carotenes**	Wallert (1995c)	
***Daemonorops* spp.** *D. draco*; *D. propinquus*	Palmae	Dragon's blood	**Dracoflavan A**, **Dracooxepine**, **Dracorubin**, **Nordracorubin** plus various methoxyflavan compounds		
***Damnacanthus* spp.** *D. major* Sieb. and Zucc. (var. *parvifolius* Koidz.)	Rubiaceae	Madder	*D. macrophyllus* contains Pelargonidin 3-rutinoside	Schweppe & Winter (1997)	
***Dracaena* spp.** *D. draco* (L.) L.; *D. ombet* Kotschy & Peyr.; *D. schizantha* Baker; *D. serrulata* Baker; *D. cinnabari* Balf. f. (and others)	Dracaenaceae	Dragon's blood	**Dracoresinotannol**, **Dracoresene** plus terpenes and other flavonoid compounds	Edwards et al (1997)	Exact species use for pigment production uncertain; those listed are principals.
***Eucalyptus* spp.** *E. resinifera* Sm.; *E. terminalis* F. Muell.	Myrtaceae	Dragon's blood		Edwards et al (1997)	Formed as an ant gall
***Galium* spp.** *G. verum* L.	Rubiaceae	'Ladies bedstraw'	**Pseudopurpurin**; 2-hydroxyanthraquinone, alizarin-1-methyl ether, alizarin, xanthopurpurin, rubiadin, purpurin, lucidin	Schweppe & Winter (1997)	*G. mollugo* also contains apigenin and luteolin glucosides
***Garcinia* spp.** *G. hanburyi*; *G. morella*; *G. cambogia* Desrouss.; *G. elliptica* Wall.; *G. heterandra* Wall.	Guttiferae	Gamboge	**Gambogic acid**; **Morellic acid**; **Isomorellic acid**	Winter (1997)	
***Gardenia* spp.** *G. jasminoides* Ellis	Rubiaceae	Gardenia seed	**Crocetin**	Yü (1955)	
***Genista* spp.** *G. tinctoria* L.	Leguminosae	Genista	**Genistein**, **Luteolin**. Other *G.* spp. also contain formononetin, prunetin, orobol 7-*O*-sophoroside and orientin 4'-glucoside	Norgate, cf. Harley (1982) 107; Sanyova & Wouters, 1994)	
***Gentiana* spp.** *G. lutea* L.	Gentianaceae	'Wongshy red' (obsc.)	**Gentisin**, **Isogentisin**	Salter (1869) 180; Schweppe (1992)	*G.* spp.: Gentiocyanins A-C, isorientin & derivatives, isosaponarin & isoscoparin. Individual spp. contain a variety of other

[15] Dye components were primarily derived from Schweppe (1992) unless superceded by more recent studies; these alternate sources are noted in the literature column. Flavonoids were also checked from Harborne and Baxter (1999).
[16] Current plant taxonomy has been checked using: Mabberley, D.J. *The Plant-Book. A portable dictionary of the vascular plants* 2nd ed., Cambridge University Press, Cambridge (1997).

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GENUS/SPECIES	FAMILY	TRIVIAL DYE NAME	DYE COMPONENTS[15]	LITERATURE	NOTES
					flavonoids.
***Glycyrrhiza* spp.** *G. glabra* L.	Leguminosae	Liquorice	*G. glabra*: Glabranin, glabrene, glabridin, glabrol, glabrone, glycycoumarin, glyzaglabrin, glyzarin, hispaglabridin A & B, isoglycocoumarin, isoliquiritigenin (glycoside), isoliquiritin, isomucronulatol, kaempferol (glucoside), licochalcone A & B, licoflavanone, licoricidin, licuroside, neoisoliquiritin, prunetin and rhamnoliquiritin	White (1986)	
***Haematoxylum* spp.** *H. campechianum* L.; *H. brasiletto* Karsten	Leguminosae	'Logwood' (also 'Campeachy wood') and 'Peachwood' respectively	**Haematin**	Harley (1982) 64-65 for logwood	
***Indigofera* spp.** *I. tinctoria L.*; *I. suffruticosa* Mill. ssp. suffruticosa & ssp. guatemalensis Kort & Thijsse; *I. arrecta* Hochst. ex A. Rich; *I. argentea L.*	Leguminosae	Indigo	**Indigo**	Widely recognized; rev.: Schweppe (1997)	Use of spp. other than *I. tinctoria* as pigments uncertain
***Iris* spp.** *I. germanica* L.	Iridaceae	Iris green	*I.* spp.: Irigenin, malvidin, negretein, petanin, petunidin *I. germanica:* **Mangiferin** [Schweppe, 1992]	*Art of Drawing* (1731), *cf.* Harley (1982) 86	
***Isatis* spp.** *I. tinctoria* L.; *I. aleppica* Scop.; *I. alpina* Vill.; *I. indigotica*	Cruciferae	Woad (indigo)	**Indigo**	Harley (1982) 66-67	Use of spp. other than *I. tinctoria* as pigments uncertain
***Juglans* spp.** *J. nigra* L.; *J. regia* L.	Juglandaceae	Walnut	**Juglone**	Thompson (1935)	
***Lilium* spp.**	Liliaceae	e.g., 'Lily green'		*Art of Drawing* (1731), *cf.* Harley (1982) 86	Probably erroneous – likely to refer to iris
***Maclura* spp.** *M. tinctoria* (L.) Steudel	Moraceae	'Old fustic'	**Morin** [Dihydromorin; 5,7-Dihydroxy-6-*C*-prenyl-flavanone]	Harley (1982) 104-105	Formerly *Chlorophora tinctoria* (L.) Gaud. and *Morus tinctoria* L.; also 'mulberry'
***Morinda* spp.** *M. citrifolia* L.; *M. umbellate* L.; *M. longiflora* G. Don.	Rubiaceae	Madder	**Soranjidiol**; **Morindone**; **Rubiadin-1-methyl ehter**; Alizarin-1-methyl ether; Rubiadin-1-methyl ether; Alizarin; Rubiadin; Damnacanthol; Damnacanthal; Nordamnacanthal; Xanthopurpurin; Morindanigrin	Schweppe & Winter (1997)	
***Morus* spp.**	Moraceae	Mulberry		Boyle (1731) *cf.* Harley (1982) 118	Probably erroneous (see text)
***Oldenlandia* spp.** *O. umbellate* L.	Rubiaceae	Madder	**Anthragallol-1,3-dimethyl ether**; **Anthragallol-1,2-dimethyl ether**; **Alizarin**; 2-Hydroxyanthraquinone; Alizarin-1-methyl ether; Hystazarin monoethyl ether	Schweppe & Winter (1997)	
***Parietaria* spp.** *P. judaica* L.; *P. officinalis* L.	Urticaceae	Nettle		Bosch (1961), used as green in Islamic bookbinding	
***Pentaglottis* spp.** *P. sempervirens* (L.) L. Bailey	Boriginaceae	Alkanet			Doubtful use
***Petroselinum* spp.** e.g., *P. crispum* (Miller) A.W. Hill	Umbelliferae	Parsley	**Apigenin-7-apiosylglucoside**; Apigenin-7-D-glucoside; Apigenin-7-glucoaposide; Luteolin-7-apiosylglucoside; Luteolin-7-diglucoside	Turner (1998) from Alcherius/Lebegue (Merrifield (1849)	
***Phellodendron* spp.** *P. amurense* Rupr.	Rutaceae	Amur cork tree	**Phellodendrine**; **Magnoflorine**; **Berberine**; **Palmatine**	Shimoyama et al (1995) in *Ukiyo-e* prints; Gibbs & Seddon (1998)	
***Polygonum* spp.** *P. tinctorium* Ait.	Polygonaceae	Knotgrass	**Indigo**	Shimoyama et al (1995) in *Ukiyo-e* prints	
***Quercus* spp.** *Q. velutina* Lam.	Fagaceae	Quercitron	**Quercetin** [Quercetagetin; Flavine]	Harley (1982) 114-115	Formerly *Q. tinctoria*
***Reseda* spp.** *R. luteola* L.	Resedaceae	Weld	**Luteolin**		
***Rhamnus* spp.** *R. cathartica* L.; *R. frangula* L.; *R. saxatilis* Jacq.	Rhamnaceae	Persian-/Avignon-/Yellow-berries	**Rhamnetin**; **Quercetin**; **Emodin** [Rhamnocathartin; Rhamnotannic acid; Rhamnin]	Widely recognised (e.g., Harley (1982)	Syn. (*R. saxatilis*): *R. infectoria*
***Rheum* spp.** *R. palmatum*	Polygonaceae	Rhubarb	Chrysophanic acid		
***Rubia* spp.** *R. tinctorum* L.; *R. peregrina* L.; *R. cordifolia* L.; *R. sikkimensis* Kurz; *R. iberica* C. Koch; *R. akane* Nakai	Rubiaceae	Madder	**Alizarin**; **Pseudopurpurin**; **Purpurin**; **Munjistin**; **Ibericin**; **Lucidin**; Xanthopurpurin; Rubiadin; 2-Hydroxyanthraquinone; Xanthopurpurin-3-methyl ether; Alizarin-1-methyl ether; Anthragallol; Nordamnacanthal; 1,4-Dihydroxy-6-methylanthraquinone; 1-Hydroxy-2-methylanthrraquinone; 1,8-dihydroxy-3-methyl-6-methoxyanthraquinone	Widely recognized (e.g., Schweppe & Winter, 1997)	
***Ruta* spp.** *R. graveolens* L.	Rutaceae	Rue		Turner (1998) from Alcherius/Lebegue (Merrifield (1849)	
***Sambucus* spp.** *S. ebulus* L.	Caprifoliaceae (Sambucaceae/Adoxaceae)	Turnsol?	**Cyanidin glycoside**	*Nurnberg Kunstbuch*; cf. Ploss (1962)	
***Sanguisorba* spp.** *S. officinalis* L.	Rosaceae	Cremisi		Merrifield (1849)	
***Serratula* spp.** *S. tinctoria* L.	Asteraceae	Sawwort	**Apigenin**; **Luteolin**		
***Sophora* spp.** *S. japonica* L.	Leguminosae	Sophora yellow	**Kaempferol**	Yü (1955)	
***Sorghum* spp.** *S. vulgare* Pers. var. Durra Hubbard et Rehd.	Graminaceae	'Sorgho red' (obsc.)	Pelargonidin; Petunidin; Cyanidin		
***Tragopogon* spp.** *T. pratensis* L.	Compositae	Plant: 'Yellow goat's beard' Pigment: Giallo santo		Merrifield (1849) 708	
***Uncaria* spp.** *U. gambier* (Hunt.) Roxb.	Rubiaceae	Japan earth; Pale catechu	**D-Catechin**; Gambirtannin; Oxogambirtannin; Dihydrogambirtannin; Quercetin; Rutin	Harley (1982) 156	
***Vaccinium* spp.** *V. mytillus* L.	Ericaceae	Bilberry	**Delphinidin-, Cyanidin-, Petunidin- and Malvidin-glycosides**	Boltz (1549); *Nurnberg Kunstbuch* (?)	
***Viola* spp.**	Violaceae	Violet	**Violanin**	BM MS Additional 23080, *cf.* Harley (1982) 86	
***Xanthorrhoea* spp.** *X. australis*; *X. johnsonii; X. preissii*	Xanthorrhoeaceae	Grass tree	**Pinocembrin**; Xanthorrhoein; Xanthorrhoeol; Hydroxyxanthorrhoein	Mills & White (1994)	

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GENUS/SPECIES	FAMILY	TRIVIAL DYE NAME	DYE COMPONENTS[15]	LITERATURE	NOTES
LICHENS:[17]					
***Bryoria* spp.** *B. capillaris; B. glabra; B. trichodes*	Parmeliaceae			Moerman (1998)	Burnt to produce a black
***Evernia* spp.** *E. prunastri*	Parmeliaceae			Wallert (1986)	
***Lasallia* spp.** *L. papulosa* (Ach.) Llano; *L. pustulata* (L.) Mérat	Umbilicareaceae	Cudbear			
***Ochrolechia* spp.** *O. parella* (L.) Massal; *O. tartarea* (L.) Massal.	Pertusariaceae	Archil; Cudbear; Litmus; Orseille; Parelle		Diadick Casselman (2002)	Formerly *Lecanora* Also given as *Ochrolechia* spp.
***Parmelia* spp.** *P. omphalodes* (L.) Ach.; *P. saxatilis* (L.) Ach.	Parmeliaceae			Wallert (1986)	
***Physcia* spp.**	Physciaceae				
***Roccella* spp.** *R.* babingtonii; R. *fimbrata; R. fuciformis* (L.) D.C.; *R. montagnei* Bél.; *R. phycopsis* (Ach.); *R. tinctoria*	Roccellacae	Litmus; Orchil		Harley (1982) 63-64	
***Variolaria* spp.** *V. orcina*				Wallert (1986)	
***Xanthoria* spp.** *X. elegans*	Teloschistaceae			Moerman (1998)	
SCALE INSECTS:[18]					
***Dactylopius* spp.** *D. coccus* Costa; *D. confusus* Cockerell; *D. ceylonicus* Green; *D. tomentosus* Lam.	Dactylophidae	Cochineal	**Carminic acid**	Schweppe & Roosen-Runge (1986)	
***Kermes* spp.** *K. ballotae*; *K. vermilio* Planch.	Kermesidae	Kermes	**Kermesic acid** [Flavokermesic acid]	Schweppe & Roosen-Runge (1986); Sanyova & Wouters (1994)	*K. vermilio* is the primary source
***Kermococcus* spp.** *K. illicis* L.	Kermesidae	Kermes	**Kermesic acid**	Schweppe & Roosen-Runge (1986)	Mentioned in literature; however, a dyestuff cannot be derived from it
***Kerria* spp.** *K. (Kerria) lacca lacca* Kerr; *K. (Kerria) chinensis chinensis* Mahdihassan	Kerriidae	Lac	**Laccaic acids A-B** [Laccaic acids C-E]	Schweppe & Roosen-Runge (1986); Cardon (1990)	*K. lacca* also known historically as *Coccus laccae*, *Laccifer lacca* and *Tachardia lacca*
***Porphyrophora* spp.** *P. polonica* L. & *P. hameli* Brandt	Margarodidae	Polish cochineal (*P. polonica*) Armenian/Ararat cochineal (*P. hamelii*)	**Carminic acid** [Kermesic acid; Flavokermesic acid]	Schweppe & Roosen-Runge (1986)	
SHELLFISH:[19]					
***Bolinus* spp.** *B. brandaris* (Linnaeus, 1758)	Muricidae: Muricinae	'Tyrian purple'	**Bromoindigo compounds**		Formerly *Murex (phyllonotus) brandaris*
***Nucella* spp.** *N. lapillus* (Linnaeus, 1758)	Muricidae: Thaidinae	'Tyrian purple'	**Bromoindigo compounds**		
***Phyllonotus* spp.** *P. trunculus* (Linnaeus, 1758)	Muricidae: Muricinae	'Tyrian purple'	**Bromoindigo compounds**		Formerly *Murex (phyllonotus) trunculus*
***Purpura* spp.** *P. patula* (Linnaeus, 1758); *P. p. pansa* (Gould, 1853); *P. aperta* (Blainville, 1832)	Muricidae: Thaidinae	'Tyrian purple'	**Bromoindigo compounds**		Some confusion over *P. patula/pansa* species differentiation. Also, some sources give this as *Plicopurpura*.
***Rapana* spp.** *R. venosa* (Valenciennes, 1846); *R. bezoar* (Linnaeus, 1767)	Muricidae: Rapaninae	'Kaimurasaki' (= 'Tyrian purple')	**Bromoindigo compounds**		Syn. (for *R. venosa*): *R. thomasiana* (Crosse, 1861)
***Stramonita* spp.** *S. haemastoma* (Linnaeus, 1766)	Muricidae: Thaidinae	'Tyrian purple'	**Bromoindigo compounds**		
***Thais (Reisha)* spp.** *T. bronii* (Dunker, 1860); *T. clavigera* (Kuster, 1860)	Muricidae: Thaidinae	'Kaimurasaki' (= 'Tyrian purple')	**Bromoindigo compounds**		
SEPIA:					
***Sepia* spp**. *S. officinalis* L. (probably also *S. o. hierredda* and *S. o.* vermiculata)	Sepiidae	Sepia	**Eumelanin**		

B.II. CARBON-BASED BLACKS, HYDROCARBONS, ETC.

α	β	γ	δ	ε	GROUP	SUB-GROUP	NAME	VARIANT FORM	CHEMICAL COMPOSITION	LITERATURE	Notes
CARBON-BASED BLACKS:											
1	1	2	1		**Carbon**	*Chars*	Bark chars	From *Betula* spp. ('Swedish black')	[Complex]	Winter (1983)	
1	1	2	2		**Carbon**	*Chars*	Bark chars	From *Quercus suber/occidentalis* spp. ('Cork')	[Complex]	Winter (1983)	

[17] Current lichen terminology is complex, but has been checked where possible from the following sources. *Parmelia* spp.: Farr, E.R.; Hale, B.W.; DePriest, P.T. *Parmeliaceae: Searchable List of Names in the Parmelioid Genera (Lichens)* (1999) (http://persoon.si.edu/parmeliaceae/; May 2003).

[18] Current terminology for the scale insects has been checked using ScaleNet (http://www.sel.barc.usda.gov/scalenet/scalenet.htm; May, 2003). Additional information on historical terminology has been provided by Dr. Yair Ben-Dov, Department of Entomology, Agricultural Research Organization, Israel (*pers. comm.*, 14/06/02).

[19] Current terminology for the Muricidae has been checked using the following sources: Abbott, R. Tucker *American Seashells: The Marine Mollusks of the Atlantic and Pacific Coasts of North America* 2nd ed., Van Nostrand Reinhold, New York (1974); Higo, Shun'ichi; Callomon, Paul; Goto, Yoshihiro *Catalogue and Bibliography of the Marine Shell-bearing Mollusca of Japan* Elle Scientific Publications, Japan (1999); Radwin, G.E.; D'Attilio, A. *Murex shells of the world. An illustrated guide to the Muricidae* Stanford University Press, Stanford (1976); Sabelli, Bruno; Giannuzzi-Savelli, Riccardo; Bedulli, Daniele *Catalogo Annotato dei Molluschi Marini del Mediterraneo* {*Annotated Check-list of Mediterranean Marine Mollusks*}, 3 vols., Libreria Naturalistica Bolognese, Bologna (1990).

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α	β	γ	δ	ε	GROUP	SUB-GROUP	NAME	VARIANT FORM	CHEMICAL COMPOSITION	LITERATURE	Notes
1	1	2	3		**Carbon**	*Chars*	Fruitstone chars	*et. seq.* From various fruit kernels, e.g. of peach (*Prunus persica*), cherry (*Prunus* spp.), date (*Phoenix dactylifera*), almond (*Prunus amygdalus*), walnut (*Juglans* spp.), coconut (*Cocos nucifera*) *etc*	[Complex]	Winter (1983)	
1	1	2	4		**Carbon**	*Chars*	Paper chars		[Complex]	Winter (1983)	
1	1	2	5		**Carbon**	*Chars*	Wood chars	From *Fagus* spp. (notably *F. sylvatica*)	[Complex]	Winter (1983)	
1	1	2	6		**Carbon**	*Chars*	Wood chars	From *Vitis* spp.	[Complex]	Winter (1983)	
1	1	3	1		**Carbon**	*Cokes*	Bone cokes	*et. seq.* From various bone sources	[Complex]	Winter (1983)	
1	1	3	2		**Carbon**	*Cokes*	Ivory cokes	*et. seq.* From various ivory sources	[Complex]		
1	1	3	3		**Carbon**	*Cokes*	Yeast cokes	From *Saccharomyces* spp.	[Complex]	Winter (1983)	
1	1	4	1		**Carbon**	*Flame carbons*	From hydrocarbon sources	'Acetylene black'	[Complex]	Winter (1983)	
1	1	4	2		**Carbon**	*Flame carbons*	From hydrocarbon sources	'Channel black'	[Complex]	Winter (1983)	
1	1	4	3		**Carbon**	*Flame carbons*	From hydrocarbon sources	'Lamp black'	[Complex]	Winter (1983)	
1	1	4	4		**Carbon**	*Flame carbons*	From combustion of wood	'Chinese ink' (from combustion of pine wood (*Pinus* and other spp.)	[Complex]	Winter (1983)	
1	1	4	5		**Carbon**	*Flame carbons*	From combustion of wood	Bistre (e.g., from *Fagus* spp)	[Complex]	Winter (1983)	
HYDROCARBONS:											
2	1	1			**Hydrocarbons**	*Coals*	Peat		[Complex]		
2	1	2			**Hydrocarbons**	*Coals*	Coal		[Complex]		
2	2	1			**Hydrocarbons**	*Coals*	Lignite		[Complex]		
2	2	2			**Hydrocarbons**	*Coals*	Anthracites		[Complex]		
2	2	3			**Hydrocarbons**	*Coals*	Humic Earths		[Complex]		
2	2	4			**Hydrocarbons**	*Synthetics*	Petrochemical derived asphalts		[Complex]		
2	2	5			**Hydrocarbons**	*Bitumen*	Naturally derived asphalts		[Complex]		
2	2	6			**Hydrocarbons**	*Amber*	Amber		[Complex]		
TANNINS:											
3	1	1			**Tannins**[20]	*Gallotannins*	Catechin		[Complex]		

B.III. EARTH PIGMENTS

α	β	γ	δ	ε	GROUP	SUB-GROUP	NAME	VARIANT FORM	CHEMICAL COMPOSITION	LITERATURE	Notes
EARTH PIGMENTS:											
1	1	1			**Earth pigments**	*Ochres*			[Complex]	Widely recognised	
1	2	1			**Earth pigments**	*Siennas*			[Complex]	Widely recognized	
1	3	1			**Earth pigments**	*Umbers*			[Complex]	Widely recognized	
1	4	1			**Earth pigments**	*Wads*			[Complex]	[See this volume]	
1	5	1			**Earth pigments**	*Green earths*			[Complex]	Widely recognized. Rev.: Grissom (1986)	

[20] So-called 'condensed' tannins are now generally classed as flavonoids (proanthocyanidins).

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