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Front cover: Yellow Arenosol, Northern Wheatbelt, Western Australia, Photo DPIRD, WA.

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Raymond Frederick Isbell (1928–2001)

Ray Isbell had a distinguished international career as a soil scientist, specialising in soil characterisation, distribution, genesis and classification. He was recognised overseas and at home as the Australian pedologist with the widest experience of Australian and world soils. He traveled extensively in the tropics and worked on comparative pedology, particularly in Africa and South America.

Ray graduated as a geologist and commenced his soil science career with the Queensland Bureau of Investigation where he was involved in soil surveys and soil assessment for proposed irrigation areas and other land development releases in southern and central Queensland. He joined CSIRO in 1958 and embarked upon a study of lands in eastern Australia dominated by brigalow (Acacia harpophylla). This sparked Ray’s interest in cracking clay soils and led to an input into the development of the Ug classification in the Factual Key (Northcote 1979).

Ray was responsible for the compilation of the Atlas of Australian Soils for substantial parts of Queensland. These 1:250,000 compilation sheets have been widely used for extension and research purposes, and for large areas of Queensland remain as the best soil information available.

Ray was involved in the preparation of the CSIRO Division of Soils book Soils: An Australian Viewpoint, both as a contributor and in an editorial capacity. This was a benchmark publication in soil science, bringing together the accumulated knowledge of Australian soil science over the last 50 years. He was also involved in the preparation of the Australian Soil and Land Survey Field Handbook, which established standardised methods for describing soil and land attributes in Australia. He was also co-editor and contributor to a book entitled Australian Soils – The Human Impact, which looked at the management of Australian soils over the last 40,000 years of human habitation. During the 1980s Ray was member of several international committees set up by the United States Department of Agriculture to advise on improvements to Soil Taxonomy in relation to oxic soils and cracking clays.

Since the mid to late 1980s, Ray’s major research activity was development of the Australian Soil Classification. The decision to develop a new classification system was taken after a survey of members of the Australian Soil Science Society and considerable discussion on alternative approaches. While it was to be the task of a Technical Committee under the auspices of the Standing Committee on Soil Conservation, Ray inherited sole responsibility for development of the new system with the support of many within the Australian soil science community.

Development of the Australian Soil Classification was grueling and technically demanding but Ray was a good listener, and he communicated regularly with pedologists not only in Australia and New Zealand but also across the world in his quest to devise the system. He built networks and established a rapport with a younger generation of pedologists as he tested the classification during its three approximations and after the official publication of the 1st Edition in 1996. Always ready to share his knowledge, he inspired colleagues during his field visits to assess the many classification challenges presented. One of his golden rules was to describe and interpret the soil profile accurately so that it could be classified with a minimum of fuss. The result was a unique personal understanding of Australian soils and this knowledge, combined with his great diplomacy and excellent judgement, has produced the best and, to date, most widely accepted national classification of Australian soils.

In retirement, but supported by CSIRO, Ray worked tirelessly to share his knowledge of Australian soils and landscapes. He continued to publish and maintained an active dialogue.
with soil scientists around the world. He continued to refine the Classification and, although clearly ill and almost totally dependent on his friends for personal help and transport, he actively contributed to the Australian Collaborative Land Evaluation Program. During this time he developed close links with the CSIRO Land & Water pedology group in Canberra, became a valued mentor, teacher and friend, and contributed significantly to a forthcoming book on Australian soil. After a long illness, Ray Isbell died in December 2001 at the age of 73.

**National Committee on Soil and Terrain (NCST)**

The NCST is the peak national committee overseeing national standards in soil characterisation and description. The NCST, through its subcommittee the Australian Soil Classification Working Group, is responsible for revisions of the Australian Soil Classification since the publication of the First Edition. The Working Group comprises Bernie Powell (Chair), Noel Schoknecht, Ted Griffin, Ben Harms, Mark Imhof, James Hall, Brian Lynch, Mark Thomas, David Rees and David Morand.

More information about the history of the Australian Soil Classification is provided in Appendix 6.
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Acknowledgements

A large number of people over a long period of time greatly assisted in the development of the Australian Soil Classification. A particular debt is owed to all State and Territory organisations and their soil surveyors who made possible numerous and informative field trips with Ray Isbell, and who contributed constructive comments on the various drafts of the publication and made available a great deal of unpublished data. The West Australian, Victorian, New South Wales and Riverina branches of the Australian Society of Soil Science organised trips and discussion groups to test earlier versions of the scheme.

Special tribute is paid to the late Ron McDonald of the Queensland Department of Primary Industries. From the inception of the project until his untimely death in 1989, Ron was a never failing source of help and inspiration. It was a matter of great regret for Ray that Ron did not live to see many of his ideas and enthusiasm come to fruition. Bernie Powell, then a member of the same Department, ably carried on Ron’s role and contributed many useful ideas that greatly improved the Classification.

A number of people deserve special mention. George Hubble and Cliff Thompson, previously with CSIRO Division of Soils in Brisbane, provided the basis for the classification of the Organosols and Podosols respectively. David Maschmedt, James Hall and Bruce Billing, then members of Primary Industries, South Australia, are thanked for their considerable help with the Calcarosols and other soils. Ray’s long-time colleague in CSIRO, Graham Murtha, was an invaluable sounding board for Ray and was a constructive critic at all times. He was largely responsible for suggesting and organising the coding system, assisting with database activities, and helping to establish computer files and search programs. Warwick McDonald and Courtney Frape (CSIRO) provided database support and assistance with format and coding. Some ideas on layout were also obtained from the New Zealand Soil Classification (Hewitt 1992). The original manuscript was produced with assistance from Wendy Strauch and Helen Rodd (CSIRO, Townsville). Approximately 20 referees read all or parts of the original publication and provided many helpful suggestions to improve the text. More information about the early history of the ASC and contributors is provided in Appendix 6.

With the Third Edition, the Working Group is indebted to a number of people who assisted in its preparation. In particular, working group member Noel Schoknecht provided the detailed submission and many working drafts for an Arenosols Soil Order. Ted Griffin, Ben Harms and Brian Lynch organised database testing and Peter Wilson and Linda Gregory (CSIRO) assisted with the preparation of distribution maps. Stephen Cattle (University of Sydney) and Andrew Biggs (Queensland Department of Natural Resources and Energy) willingly provided assistance with ensuring consistency of terminology with the Yellow Book (Australian Soil and Land Survey Field Handbook).

Rob Fitzpatrick contributed data and conceptual advice on mineral sands and Rob Moreton provided supporting information on shallow peats.

CSIRO is thanked for supporting the Australian Soil Classification over a long period.
Preface to the Third Edition

With the first edition of the ASC, the availability of classified soil profiles was skewed towards Queensland (46.6%) due to the limited accessibility of good quality data. That situation has dramatically changed, with a greater proportion of quality sites from most other states or territories and a tenfold increase (from 14,045 to 143,112) in ASC classified profiles (Table 1). The available dataset is now far more representative of Australian soils and their properties.

Table 1 Number (percentage) of sites classified to at least Soil Order

<table>
<thead>
<tr>
<th>State/territory</th>
<th>Area %</th>
<th>1996</th>
<th>2018</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACT</td>
<td>&lt;1</td>
<td>42</td>
<td>731</td>
</tr>
<tr>
<td>NSW</td>
<td>10.4</td>
<td>2250</td>
<td>21326</td>
</tr>
<tr>
<td>VIC</td>
<td>3</td>
<td>1142</td>
<td>7070</td>
</tr>
<tr>
<td>QLD</td>
<td>22.5</td>
<td>6550</td>
<td>45122</td>
</tr>
<tr>
<td>SA</td>
<td>12.7</td>
<td>1524</td>
<td>19645</td>
</tr>
<tr>
<td>WA</td>
<td>33.0</td>
<td>1327</td>
<td>14721</td>
</tr>
<tr>
<td>TAS</td>
<td>0.9</td>
<td>488</td>
<td>4890</td>
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<td>NT</td>
<td>17.5</td>
<td>734</td>
<td>29607</td>
</tr>
<tr>
<td>AUSTRALIA</td>
<td>100</td>
<td>14045</td>
<td>143112</td>
</tr>
</tbody>
</table>

Sources:
1 Australian Soil Classification, First Edition (Ray Isbell 1996)
2 National soil site data collation for the Australian Soil Landscape Grid 2018 (source: Peter Wilson and Ross Searle, CSIRO)
3 Victorian soils database (source: Mark Imhof, Agriculture Victoria, 2019)

The second and third editions of the ASC have been the result of this ongoing data collection and improved understanding of gaps in soil knowledge. The second edition reflected substantially more knowledge of Australian wetland and subaqueous soils, particularly those influenced by sulfides (commonly known as acid sulfate soils) and soils dominated by ironstone gravels in Western Australia (accommodated by the Sesqui-Nodular Great Group in Tenosols).

The Working Group on Land Resource Assessment prepared the Revised Edition, published in 2002. To manage the ongoing updating of the classification, the National Committee on Soil and Terrain established the Australian Soil Classification Working Group in 2013 to assess proposals for change and make recommendations to the NCST. Following recommendations by the Working Group, in 2016 the NCST released a Second Edition to accommodate new knowledge and understanding of soils containing sulfidic materials. Included in these changes was the introduction of Subtidal and Subaqueous soils. Soils with abundant ironstone gravels were also accommodated by a Sesqui-Nodular Great Group in Tenosols.

The modifications incorporated into this Third Edition are the second approved recommendations from the Working Group. The most prominent modifications relate to definitions and expanding the key to accommodate an Arenosol Soil Order for deep sands, as proposed by Noel Schoknecht. Deep sands were formerly classified as Tenosols, Rudosols and Calcarosols. These Soil Orders have extreme morphological diversity and have been subject to extensive investigation, particularly in South Australia, south-west Western Australia and the Northern Territory.

This major change to the classification was subjected to widespread consultation with the Australian soil science community over two years. Feedback from this consultation was strongly positive but not universally so. However, it led to a number of constructive changes
Summary of changes in the Third Edition

The main changes in the Third Edition accommodate existing knowledge and understanding of the significance, nature, distribution and refined testing for soils comprising deep sands. This involved the introduction of a new Soil Order, the Arenosols. The introduction of the Arenosols Order led to a review and changes to Calcarosols, Tenosols and Rudosols. The main changes to these four orders, plus other improvements throughout the text, are summarised below:

Arenosols
The main essential changes to soils with deep sandy profiles are summarised below:

a) Deep sands (sands at least 1 m deep) formerly classified as Calcarosols, Tenosols and Rudosols now classify as Arenosols.
b) In the key to Soil Orders, the criteria for Calcarosols are changed to exclude deep sands.
c) Soils with >10% coarse fragments and/or hard segregations (by visual abundance and weighted average in the top 1.0 m) are excluded from the Arenosols Soil Order.
d) Horizon development may be absent in some Arenosols previously described as Rudosols.
e) Deep sands with pedogenic carbonates previously classified as Shelly, Calcic or Hypocalcic Calcarosols will now classify as Carbonatic or Calsilic Arenosols.
f) Additional Great Groups include Gritty (mainly granitic sands), Kandic (sandy loam Tenic B horizon - soils transitioning to a Kandosol), Gravic (heavy mineral sands) and Subhalic, Hypocalcic, Lithocalcic, Supracalcic, Hypercalcic and Calcic.
g) Text in the How to Classify section with tips on how to determine if a deep, more clayey horizon (often >1.0 m deep) is a B or D horizon.

Calcarosols
a) The Shelly Suborder has been removed, and replaced by the Carbonatic Suborder.

Rudosols
a) The Shelly definition is amended to provide clarity.
b) Coquinic, Petrocalcic, Lithic and Regolithic Great Groups are included for Shelly Rudosols.
c) The Arenic definition has been amended to be consistent with Arenosols.
d) The six Great Groups currently available for Leptic Rudosols are now available for Arenic Rudosols as well. Previously no Great Groups had been proposed for the Arenic Suborder.
e) The set of families available has been expanded from two to six, and is now consistent with other orders.

Tenosols
a) The term Orthic is now redundant and removed from Tenosol Suborders.
b) The definition of the Calcenic Suborder has been amended i.e. from ‘pedogenic carbonate’ to ‘fine-earth carbonate’.
c) For consistency, the Arenic Great Group is keyed out before Inceptic, Lithic, etc.
d) The definition of Arenic is amended (to be compatible with Arenosols).
e) Shelly Tenosols are removed and classify as either Arenosols or Rudosols.
f) Various gritty Great Groups are added
g) The 13 Subgroups previously available for Bleached-Orthic are now available for the coloured Suborders as well, but four Subgroups are no longer available (Subpeaty, Subhumose, Submelacic and Submelanic).

Other changes
Other important, but less substantial, changes are incorporated into the Third Edition. These mainly aim to improve clarity and consistency, and also align with definitions in the Australian Soil and Land Survey Field Handbook (NCST 2009), referred to here as the Yellow Book. These include:

a) An amended Figure 1 to match the order in the Key to Soil Orders.
b) Each Soil Order is accompanied by a map of its distribution.
c) Where appropriate, ‘B2’ horizon is replaced by ‘B2t’.
d) In the key, the term ‘structure’ is replaced by ‘grade of pedality’.
e) The term ‘fragments’ is replaced with ‘particles’.
f) ‘Soft, finely divided carbonate’ is replaced with ‘fine-earth carbonate’.
g) To improve clarification of terminology, the glossary has been expanded with additional terms and definitions, including some from the Yellow Book.
h) Some definitions in the glossary have been amended to align with the Yellow Book. In some cases the definitions have been changed in both publications – these changes will be reflected in the new edition of the Yellow Book.
i) Colour classes are explained more fully, including a table in colour.
j) Confidence levels have been rewritten for greater clarity.
k) Several new references are included and some older ones updated.
l) The definition of shallow Organosols is expanded to allow the presence of unconsolidated material no thicker than the organic materials above.
m) Addition of a water repellence Family criterion for surface soils of susceptible Orders.
Background

Classification is a basic requirement of all science and needs to be revised periodically as knowledge increases. It serves as a framework for organising our knowledge of Australian soils and provides a means of communication among scientists, and between scientists and those who use the land. The history of soil classification in Australia was reviewed by Isbell (1992), who noted that two classification schemes were widely used prior to 1996. The Handbook of Australian Soils (Stace et al. 1968) was largely a revision of the earlier great soil group scheme (Stephens 1953). The Factual Key (Northcote 1979) dates from 1960 and was essentially based on a set of about 500 profiles largely from south-eastern Australia. Moore et al. (1983) have discussed the advantages and disadvantages of these two schemes. The history of the development of the Australian Soil Classification is summarised in earlier editions and is presented in Appendix 6. A number of options were considered before deciding on the current form.

Over the past five decades a vast amount of soils data has accumulated, with considerable new information being collected in wetland environments, and in the Northern Territory and Western Australia since the first edition was published. This information needed to be incorporated into any new or revised national soil classification. The second edition mainly accommodates new knowledge about acid sulfate soils (sulfidic and sulfuric concepts) and introduces a new Sesqui-Nodular Suborder to the Tenosols. This Third Edition introduces a new Soil Order for deep sands, the Arenosols.

It is important to note that reference to the frequency or likelihood of occurrence of certain soil classes throughout the key is based on the data available at the time of first edition publication.

The selected option for a new Australian classification system was for a multi-categoric scheme with classes defined on the basis of diagnostic horizons or materials and their arrangement in vertical sequence as seen in an exposed soil profile, that is, soil rather than geographic attributes were to be used. In the new scheme, classes are based on real soil bodies, they are mutually exclusive, and the allocation of 'new' or 'unknown' individuals to the classes is by means of a key.

The guiding principles agreed to were:

- The classification should be a multi-categoric scheme with classes defined on the basis of diagnostic horizons or materials and their arrangement in vertical sequence as seen in an exposed soil profile, that is, soil rather than geographic attributes were to be used.
- It is important to note that reference to the frequency or likelihood of occurrence of certain soil classes throughout the key is based on the data available at the time of first edition publication.
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- The guiding principles agreed to were:
  - a) The classification should be a general purpose one as distinct from a technical or special purpose scheme.
  - b) It should be based on Australian soil data and as far as possible the selected attributes should have significance to land use and soil management.
  - c) It should be based on defined diagnostic attributes, horizons, or materials, the definitions of which, where appropriate, should be compatible with those of major international classification schemes.
  - d) The entity to be classified is the soil profile, with no depth restrictions except for the 1 m depth criterion for the Arenosol Order.
  - e) Although the soil classification should be based as far as practicable on field morphological data, laboratory data must be used as appropriate. If possible, more use should be made of soil physical and engineering properties.
  - f) The scheme should be based on what is actually there rather than on what may have been present before disturbance by humans. Surface horizons should not be defined in terms of an 'after mixing' criterion as in Soil Taxonomy.
  - g) The scheme should be a multi-categoric one, arranged in different levels of generalisation.
  - h) The scheme should be flexible enough to accept new knowledge as it becomes available -
it should be open-ended.

i) The classification should give emphasis to relatively stable attributes as differentiae.

j) The nomenclature must not be too complex, but be unambiguous.

The general guidelines above have mostly been followed in the new scheme. Unfortunately, because of lack of data, it has not been possible to make more use of soil physical and engineering properties.
How to Classify

What do we classify?

Because soils are three dimensional bodies their classification has always caused problems. In practice, in most countries, the entity classified is the soil profile, which is a vertical section through the soil from the surface through all of its horizons to the parent or substrate material. However, the lateral dimensions of the section may range from about 50 mm to a metre or more depending on the method of examination.

It is sometimes difficult to distinguish soil from its parent material or underlying substrate, and to distinguish between soil and ‘not soil’. Most concepts of soil involve the idea of an organised natural body at the surface of the earth that serves as a medium for plant growth. However, most engineers and geologists tend to regard soils mainly as weathered rock or regolith. The first edition of Soil Taxonomy (Soil Survey Staff 1975) noted that the lower limit of soil is normally the lower limit of biologic activity, which generally coincides with the common rooting depth of native perennial plants. There are obvious problems with the latter part of this concept, and in Soil Taxonomy the lower limit of the soil that is classified is arbitrarily set at 2m. This approach is rejected in the new classification, and the term pedologic organisation (McDonald et al. 1990) is used to distinguish soil materials. This is a broad concept used to include all changes in soil material resulting from the effect of the physical, chemical and biological processes that are involved in soil formation. Results of these processes include horizonation, colour differences, presence of pedality, texture and/or consistence changes. Obviously there are some difficulties in this approach, such as distinguishing between a juvenile soil and recently deposited sedimentary parent material.

In some Arenosols and Rudosols there may be negligible, if any, horizon development. Subjective judgement is often required, as in distinguishing between the Rudosols with only rudimentary pedologic organisation as opposed to slight development in the Tenosols. In the special case of the Anthroposols - the ‘human-made’ soils - some departure from the above concept of soil is necessary. In this Order human activities may have been mainly responsible for the creation of ‘non-natural’ parent materials as well as ‘non-natural’ alteration processes such as profound disturbance by mechanical or other means, or the addition of a wide range of anthropogenic materials to surface soils, including toxic chemical wastes.

In classifying the soil profile, it is necessary to identify various diagnostic horizons and materials. All terms used in the classification are consistent with those defined in the Third Edition of the Australian Soil and Land Survey Field Handbook (NCST 2009), or else are defined in the Glossary.

One of the most important features used in the classification is the B horizon. In some soils it may be present in variable amounts mainly in fissures in the parent rock or saprolite but even so it can still be of importance to use of the soil. The classification of such soils leads to a consideration of transitional horizons viz. BC, B/C and C/B. If the B horizon material occupies more than 50% (visual abundance estimate) of the horizon, i.e. it is a B, BC or B/C horizon, the soil is deemed to possess a B horizon and is classified accordingly. If, however, the soil has a C/B horizon in which the B horizon component is between 10% and 50%, the soil will be classed as a Tenosol. If there is less than 10% of B horizon material and no pedological development other than a minimal A1 horizon, the soil would be classed as a Rudosol.

Although it is difficult to avoid genetic implications, it should be noted that a B horizon, for example, is identified by what it is, not by how it got there. Thus if there is a sequence where a sandy sedimentary layer overlies a clayey sedimentary layer and the system has been operating as a whole for sufficient time for soil forming factors to influence both, and also
for the properties of one layer to influence the properties of the other, there is no reason why we cannot speak of these transformed layers as A and B horizons and classify the soil accordingly. Evidence of transformation commonly takes the form of the presence of an A2 horizon and an absence of a B horizon (commonly Tenic) in the sandy material immediately above the clayey sedimentary layer. If there is no apparent transformation (commonly the presence of a B horizon in the sandy sedimentary layer above), the clayey sedimentary layer may be considered a lithologic discontinuity and identified as a D horizon.

If a buried soil cannot be classified, the sequence may be recorded as in the following example: Grey Kandosol/sulfidic clayey D horizon. In this example the buried soil has a clayey texture, using the same texture categories as in the Family criteria.

Another situation which not uncommonly arises is the formation of a new soil in the A horizon of a pre-existing soil. This may also be covered as in the following example: Humosesquic, Semiaquic Podosol f Chromosolic, Redoxic Hydrosol. The symbol f indicates that the first named soil is forming in the A horizon of the second named soil.

**Nature of the classification**

The scheme is a general purpose, hierarchical one (Order, Suborder, Great Group, Subgroup, Family) and a diagrammatic view is shown in Figure 1.

![A classification system for Australian Soils](image)

**Figure 1.** Simplified key to the Orders.

Note that this figure is a guide only and should not be used as a replacement for the complete key.

All hierarchical schemes have both advantages and disadvantages. Among the former is the flexibility to classify a soil at whatever level of generalisation is desired. A perceived disadvantage is that as soils are grouped into higher categories, the assertions that can be
made about any group become progressively fewer. This explains why some high-level groupings e.g. the Order Dermosols, can be criticised as containing a diverse range of soils. The goal of all successful hierarchical systems is to use criteria at the higher categories that carry the most accessory features along with those criteria.

Another related issue is some lack of consistency in the use of certain criteria in the hierarchy. The general philosophy, following Soil Taxonomy, has been to select differentiae which seem to reflect the most important variables within the classes. It would be tidy, for instance, to have all Suborders based on colour. The fact is that while it is useful to use colour at the Suborder level for eight of the orders, it does not give the 'best' class differentiation for other orders where different criteria give a more effective subdivision e.g. in Podosols.

The fact that most classes are mutually exclusive inevitably means that soils on either side of a class boundary may appear to have more in common than they do with the 'central concept' of each adjoining class. An obvious example of this occurs in the Suborder classes defined by colour.

In general, intergrade soils are catered for at the Subgroup level. As an example, there are sodic and vertic Subgroups for Chromosols, which respectively indicate affinities with Sodosols and Vertosols. Another situation arises when similar soils are placed in different orders because B horizon pH is say in one soil and 5.6 in another; by definition the former soils are Kurosols and the latter Chromosols. However, the similarity between them is preserved by both orders having essentially the same Suborders, Great Groups and Subgroups.

A number of ideas have been taken from other classification schemes in Australia and overseas, e.g. the hierarchical framework of Order, Suborder, Great Group, Subgroup and Family is widely used elsewhere in the world. A number of concepts have been borrowed from Soil Taxonomy, and some have originated in the South African classification (Soil Classification Working Group 1991), for example base status classes. A number of concepts from the Factual Key have also been used e.g. the use of strong texture contrast and colour at a high categorical level. Throughout the text, where appropriate, brief reasons are given for particular decisions regarding the use of various differentiating criteria.

These are found under the heading 'Comment'. Appendix 5 shows approximate correlations between the orders of the new scheme and classes of three other classifications formerly used in Australia.

A change from previous Australian classification schemes is the use of laboratory data (mainly chemical) at some levels in a number of orders. Although some field soil surveyors have protested, no apology is made for this approach. Soil classification schemes being developed around the world are increasingly relying on laboratory data, particularly where soils with very similar morphology may have widely differing chemical properties. The same is true for most other sciences e.g. geology. In this scheme the need for laboratory data is minimised at the Order level, and where possible some guidelines are given to enable tentative field classification. A summary of the analytical requirements is given in Appendix 4.

**Operation and nomenclature**

The classification is designed in the form of a number of keys. To classify a soil profile the following procedure should be adopted.

1. Read the **Key to the Soil Orders** stepwise and select the first Order in the key that apparently includes the soil being studied, checking out diagnostic horizon definitions in the Glossary as needed.
2. Turn to the page indicated, read the definition of the Order to ensure that it embraces the soil being studied.
3. Then study the various keys to the Suborders, Great Groups and Subgroups, and select the first appropriate class where available. Note that the classes, particularly at the Subgroup level, must be examined sequentially, as they are often based on...
HOW TO CLASSIFY

differentiating criteria which are thought to be of decreasing order of importance to the use of the soil. This of course is subjective, and the Order in which the classes are arranged may be changed in the light of further knowledge.

4. If a suitable classification is not found at the Great Group or Subgroup level the classification at that level is not applicable.

5. To classify at the Family level, select the appropriate designations.

The scheme is open ended; new classes can be added if desired, although they will not necessarily follow on from the existing classes. However it is highly unlikely that any new orders will be introduced. Where possible, names are connotative, and often based on Latin or Greek roots, e.g. see Table 2. Suborder, Great Group and Subgroup class names are given in bold type after each class definition, together with their relevant codes.

This two letter code in brackets is unique for that class name. The Order code is given after the Order heading. Similarly, a one letter code is given for the Family criteria. This code system will allow recording on field sheets, and also enable various database searches to be carried out. As an example, it will allow searches for particular criteria irrespective of the hierarchical level at which they are used in the classification. Provision is also made for instances where there is no appropriate class available [code ZZ], or when it is not possible to determine the class from the available information [code YY].

Provision is also made for indicating confidence levels of the classification where class definitions involve the need for analytical data. In the Appendices the full list of class names and codes is given, together with examples of their use.

The general form of the nomenclature is as follows:
Subgroup, Great Group, Suborder, Order; Family.

An example is:
Bleached, Eutrophic, Red Chromosol; thin, gravelly, sandy/clayey, shallow.

Note that this can be shortened if desired, or if some levels of the hierarchy cannot be determined e.g. Red Chromosol; Bleached, Red Chromosol; Red Chromosol; thin, gravelly etc.

At the Subgroup level in particular, the differentiating criteria are frequently not mutually exclusive. This problem can be alleviated to some extent by combining attributes e.g. Bleached-Mottled, but usually judgement has been required in establishing the sequence of the Subgroup classes. This was largely based on a subjective assessment of the Subgroup properties in relation to use of the soil. In the six orders where the Haplic Subgroup is used it is placed last and defined as ‘other soils with a whole coloured B horizon’. It should be noted that as well as having this particular property, it also does not have any of the properties of any class that precedes it in the list of Subgroups. This is the reason for the particular class name, derived from Gr. haplous, simple.

Table 2. Soil Order nomenclature

<table>
<thead>
<tr>
<th>Name of Order</th>
<th>Derivation</th>
<th>Connotation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anthroposols</td>
<td>Gr. anthropos, man</td>
<td>'human-made' soils</td>
</tr>
<tr>
<td>Arenosols</td>
<td>L. arenum, sand</td>
<td>sandy soils</td>
</tr>
<tr>
<td>Calcarosols</td>
<td>L. calcis, lime</td>
<td>calcareous throughout</td>
</tr>
<tr>
<td>Chromosols</td>
<td>Gr. chroma, colour</td>
<td>often bright coloured</td>
</tr>
<tr>
<td>Dermosols</td>
<td>L. dermis, skin</td>
<td>often with clay skins on ped faces</td>
</tr>
<tr>
<td>Ferrosols</td>
<td>L. ferrum, iron</td>
<td>high iron content</td>
</tr>
<tr>
<td>Hydrosols</td>
<td>Gr. hydor, water</td>
<td>wet soils</td>
</tr>
<tr>
<td>Kandosols</td>
<td>Kandite (1:1) clay minerals</td>
<td>-</td>
</tr>
</tbody>
</table>
There are apparent inconsistencies in the use of A and A1 horizons at the Family level in various orders. This is deliberate, for the following reasons. In the soils with strong texture contrast, it is thought that properties of the total A horizons (i.e. A1, A2, A3) are important. In some other orders where soil changes are very gradual with depth, and it is frequently difficult to distinguish between say A3 and B1 horizons, it is thought more appropriate to use A1 horizon at the Family level. In some circumstances problems may arise with Ap horizons. In the strong texture contrast situation above, the Ap horizon will automatically be included, although in some soils with thin A horizons or where deep ploughing is practised, there is the probability that some of the B horizon will be incorporated in the Ap. In the case of A1 horizons, these will mostly equate with Ap horizons, although again there can be a problem with deep ploughing. In some A and A1 horizons, texture may not be uniform throughout. In these instances the texture of the major part of the horizon should be given.

Some soils may have surface horizons dominated by organic materials (O2 or P horizons; NCST 2009) which overlie an A1 horizon. In these cases the field texture at the Family level will be given for the O2 or P horizon, i.e. peaty. In soils with peaty or subpeaty Subgroups this will result in repetition at the Family level. See also peaty horizon.

At the Family level all textures are field textures. The percentages given in brackets are merely a guide and are based on those in NCST (2009). In contrast, the clay content classes used in Vertosols are based on actual laboratory analyses.

**Concluding Statement**

Three points concerning use of the classification need to be emphasised. First, the best place to classify a soil is in the field, where the morphological requirements can readily be checked. Even if laboratory data are required for some classes, a tentative classification can usually be made and verified later. It is important therefore to always give the confidence level of the classification (see Appendix 1). Second, to quote the South African Soil Classification Working Group (1992), "this soil classification has as its primary aim the identification and naming of soils according to an orderly system of defined classes, and so permit communication about soils in an accurate and consistent manner." Third, in the case of soil survey and mapping the use of the scheme will not be any different to that of any existing classification; it must be coupled to soil mapping for it to yield information on the geographic distribution of soils. Recommendations for classification and mapping units in Australian soil surveys are provided by Isbell (1988).

Finally, it should again be emphasised that no classification scheme is ever complete. As knowledge increases, so there must be future modifications to the scheme to incorporate this new knowledge. In this classification this axiom is particularly relevant in the case of the Anthroposols and those soils containing sulfuric and/or sulfidic materials, where at present data are very limited but extensive studies are in progress. Amendments to the classification are the responsibility of the National Committee on Soil and Terrain which has representatives from relevant Territory, State and Commonwealth agencies.
Key to Soil Orders

The material below is arranged to give the simplest way of identifying a particular soil in terms of the Orders, and is not a complete definition of each Order. Work successively through the key until an apparent identification is made, then check the full definition of the Order by going to the relevant Order page. Key words or phrases are defined in the Glossary.

A. Soils resulting from human activities.

ANTHROPOSOLS

B. Soils that are not regularly inundated by saline tidal waters and either:
   1. Have more than 0.4 m of organic materials within the upper 0.8 m. The required thickness may either extend down from the surface or be taken cumulatively within the upper 0.8 m; or
   2. Have organic materials extending from the surface to a minimum depth of 0.1 m; these either overlie unconsolidated material no thicker than the organic materials above, or directly overlie rock or other hard layers, partially weathered or decomposed rock or saprolite, or overlie fragmental material such as gravel, cobbles or stones in which the interstices are filled or partially filled with organic material. In some soils there may be layers of humose and/or melanic horizon material underlying the organic materials and overlying the substrate.

ORGANOSOLS

C. Other soils that have a Bs, Bhs or Bh horizon (see Podosol diagnostic horizons). These horizons may occur either singly or in combination.

PODOSOLS

D. Other soils that:
   1. Have a clay field texture or 35% or more clay throughout the solum except for thin, surface crusty horizons 0.03 m or less thick, and
   2. Unless too moist, have open cracks at some time in most years that are at least 5 mm wide and extend upward to the surface or to the base of any plough layer, peaty horizon, self-mulching horizon, or thin, surface crusty horizon, and
   3. At some depth in the solum, have slickensides and/or lenticular peds.

VERTOSOLS

E. Other soils that are saturated in the major part of the soil profile for at least 2-3 months in most years (i.e. includes tidal waters).

HYDROSOLS

F. Other soils with a clear or abrupt textural B horizon and in which the major part of the upper 0.2 m of the B2t horizon (or the major part of the entire B2t horizon if it is less than 0.2 m thick) is strongly acid.

KUROSOLS

G. Other soils with a clear or abrupt textural B horizon and in which the major part of the upper 0.2 m of the B2t horizon (or the major part of the entire B2t horizon if it is less than 0.2 m thick) is sodic and is not strongly subplastic.
KEY TO SOIL ORDERS

SODOSOLS

H. Other soils with a clear or abrupt textural B horizon and in which the major part of the upper 0.2 m of the B2t horizon (or the major part of the entire B2t horizon if it is less than 0.2 m thick) is not strongly acid.

CHROMOSOLS

I. Other soils that:
   1. Are either calcareous throughout the solum - or calcareous at least directly below the A1 or Ap horizon, or a depth of 0.2 m (whichever is shallower). Carbonate accumulations must be judged to be pedogenic, i.e. are a result of soil forming processes in situ (either current or relict). Soils dominated by non-pedogenic calcareous materials such as particles of limestone or shells are excluded. See also calcrete, and
   2. Do not have deep sandy profiles that have a field texture of sand, loamy sand or clayey sand in 80% or more of the upper 1.0 m.

CALCAROSOLS

J. Other soils with B2 horizons in which the major part has a free iron oxide content greater than 5% Fe in the fine-earth fraction (<2 mm). Soils with a B2 horizon in which at least 0.3m has vertic properties are excluded (see also Comment and footnote in Ferrosols).

FERROSOLS

K. Other soils with B2 horizons that have grade of pedality greater than weak throughout the major part of the horizon.

DERMOSOLS

L. Other soils that:
   1. Have well-developed B2 horizons in which the major part has a grade of pedality that is massive or weak, and
   2. Have a maximum clay content in some part of the B2 horizon that exceeds 15% (i.e. heavy sandy loam [SL+]or heavier).

KANDOSOLS

M. Other soils that have, within the upper 1.0 m of the soil profile:
   1. a sandy field texture in 80% or more of the upper 1.0 m of the soil profile (i.e. a field texture of sand, loamy sand or clayey sand); and
   2. no layer with a clay content that exceeds 15% (i.e. heavy sandy loam [SL+]or heavier); and
   3. ≤10% (by visual abundance and weighted average) of coarse fragments and/or hard segregations >2 mm in size; and
   4. no hard layers (cemented pans, other cemented materials, rock or saprock).

ARENOSOLS
Other soils with negligible (rudimentary), if any, pedologic organisation apart from the minimal development of an A1 horizon or the presence of less than 10% of B horizon material (including pedogenic carbonate) in fissures in the parent rock or saprolite. The soils have a grade of pedality of single grain, massive or weak in the A1 horizon and show no pedological colour change apart from darkening of an A1 horizon. There is little or no texture or colour change with depth unless stratified or buried soils are present. Cemented pans may be present as a substrate material. Soil may be shallow over unrelated rock.

**RUDOSOLS**

N. Other soils.

**TENOSOLS**
Anthroposols [AN]

[Pronounced An-throp-oh-sols]

Concept

These soils result from human activities which have caused a profound modification, mixing, truncation or burial of the original soil horizons, or the creation of new soil parent materials. Note that the concept of soil used in this classification of Australian soils (see Background) also applies to the Anthroposols, and hence sealed and semi-sealed surfaces such as streets, roads etc. are regarded as 'non-soil'. Also, in depositional situations, the anthropic material must be 0.3 m or more thick where it overlies buried soils. Anthropic materials <0.3 m thick will identify an anthropic phase of the soil below.

To qualify as soil an Anthroposol needs to possess some pedogenic features, as noted below. Key criteria in the identification of an Anthroposol are the presence of artefacts in the profile or knowledge that the soils or their parent materials have been made or altered by human action.

Anthroposols differ from other soils in that we normally know their origin with a degree of certainty, and hence we can invoke a knowledge of process rather than defined pedogenic attributes to initially classify the soil. We can then subdivide at the higher levels on the basis of type of process and nature of the product which forms the parent material of the new soil. At lower levels in the classification, conventional soil properties could be used when available, although obviously these will be limited in very young soils.

Definition

Soils resulting from human activities which have led to a profound modification, truncation or burial of the original soil horizons, or the creation of new soil parent materials by a variety of mechanical means. Where burial of a pre-existing soil is involved, the anthropic materials must be 0.3 m or more thick. Pedogenic features may be the result of in situ processes (usually the minimal development of an A1 horizon, sometimes the stronger development of typical soil horizons) or the result of pedogenic processes prior to modification or placement (i.e. the presence of identifiable pre-existing soil material).

Comment

It is difficult to quantify ‘profound modification, mixing and truncation’ but this would normally exclude the usual agricultural operations (including land planning) which may change a soil from say a Chromosol to a Dermosol by mixing or removal of the upper horizons. Similarly, soils that are artificially drained or flooded are not Anthroposols but may classify as different Soil Orders following a permanent change in water status (see also Comment in Hydrosols).

There will also be instances where the question is how much truncation results in ‘profound modification’ or merely a truncated phase. It is difficult to give guidelines that will cover all circumstances, and inevitably judgement is required. Similarly, there will be instances where land reclamation and restoration in the past have been so successful that little evidence of a prior disturbance remains, and soil development gives no clue to past history. A good example of this is Podosol development on restored and revegetated coastal dunes following sand mining.
ANTHROPOSOLS

Suborders

*** Soils that have surface layers at least 0.3m thick that show evidence of burnt peat (often in the form of coloured ash layers) and comprise ≥ 20% of fusic soil material.

**Fusic [IT]**

*** Soils that have been formed by applications of human-deposited materials such as mill-mud, etc. or the accumulation of shells and organic materials to form middens. (Minimum depth of burial is 0.3 m).

**Cumulic [HR]**

*** Soils that have had additions of organic residues such as organic wastes, composts, mulches, etc. that have been incorporated into the soil and obliterated pre-existing pedological features.

**Hortic [HS]**

*** Mineral soil or regolithic materials that are underlain by land fill of manufactured origin and which is predominantly of an organic nature. These materials may be of domestic or industrial origin and usually occur as artificially elevated landforms. The intent is to designate refuse from human activity high enough in organic matter to generate significant quantities of methane when placed under anaerobic conditions.

**Garbic [HT]**

*** Mineral soil or regolithic materials that are underlain by land fill of predominantly a mineral nature. The fill may be wholly of manufactured origin (glass, plastics, concrete, etc.) or contain a mixture of manufactured materials and materials of pedogenic origin. The fill usually occurs as an artificially elevated landform.

**Urbic [HU]**

*** Soils that have formed or are forming on mineral materials that have been dredged through human action from the sea or other waterways, or deposited as a slurry resulting from mining operations; e.g. tailings ponds, salt ponds, coal washing residues etc. The dredged materials commonly occur as a lithologically distinctive unit overlying (buried) flood plain surfaces. Such deposits frequently occur in coastal areas, common examples being airports, golf courses and other urban developments.

**Dredgic [HV]**

*** Soils that have formed or are forming on mineral materials that have been moved by earthmoving equipment in mining, highway construction, dam building etc. The materials contain too few manufactured artefacts to qualify as urbic soils. Landscapes are human-formed, and hence may present an 'unnatural' geomorphic expression. Spolic materials are increasingly being capped by pre-existing topsoil.

**Spolic [HW]**

*** Soils that have formed or are forming on land surfaces that have been created by humans by cutting away any previously existing soil by mechanical equipment such as bulldozers and graders. Common occurrences are found along highways where they are usually associated with fill areas with spolic materials. In some instances truncated remnants of the lower horizons of pre-existing soils may occur. Scalpic soil areas typically have peculiar geomorphic expressions, often with smooth and steep slopes.

**Scalpic [HX]**
Comment

In the Garbic, Urbic and some Spolic soils it is common practice to cover the anthropic materials with a layer of soil materials as an aid to reclamation. This soil material is regarded as part of the Suborder and can be used as a basis for lower category classification. In other situations sewage sludge is being used to rehabilitate mine spoil.

The Scalpic soils may also have material added to their new surface. If this is less than 0.3 m there would be, for example, a spolic phase of the Scalpic Suborder; if 0.3 m or more thick the soil would classify as a Spolic Suborder.

There will obviously be intergrade situations between some of the Suborders. For example, it may sometimes be difficult to decide between Garbic and Urbic, Cumulic and Hortic. In these and similar situations judgement and/or knowledge of the process will be required. With the increasing emphasis on recycling, much of the garbic materials will be composted so the garbic group could become redundant.

Another likely difficult situation results when human-induced or human-accelerated erosion has removed upper soil horizons. On present thinking it would seem more appropriate for such soils to be regarded as an eroded phase of say a Sodosol, provided the original soil can be identified.

The question of soils contaminated by toxic wastes is also unresolved. They could be included in the Garbic Suborder, but if the wastes are toxic to plant and animal life their host materials cannot strictly be regarded as soil. In some situations the problem could be overcome by referring to the site as a contaminated phase of the pre-existing soil.

Lower Categories

It is hoped that the seven Suborders will provide a conceptual framework for the classification of most anthropic soils based on human-induced processes which provide particular kinds of soil parent materials. The Suborders are a simplified relevant summary of an almost infinitely large range of anthropic processes and products. The need for subdivision below the Suborder level is likely to be more desirable in some classes than others, but a major problem in creating lower category classes is the lack of data on the morphology and laboratory properties of anthropic soils. Most information seems to be available for the spolic soils created by mining operations. Here though it may be more appropriate to create a technical classification based on reclamation needs.

For some of the Suborders, differentiae for lower categories could be based on appropriate traditional attributes used in classifying 'natural' soils, both morphologic and laboratory-determined. At present this is impractical due to the lack of an adequate representative profile data base. A related approach is to use at the Great Group level classes based on the other orders e.g. Chromosolic, Sodosolic etc. as has been done for the Hydrosol Great Groups. In this approach Rudosolic Spolic Anthroposols would obviously be a very common class. A wide range of options is available for Subgroup differentiae, but existing Family criteria will probably be appropriate for most Anthroposols. A preliminary approach to classifying Australian mine soils based on proposed amendments to Soil Taxonomy has been made by Fitzpatrick and Hollingsworth (1994). A number of their proposed Subgroups could be used in Spolic Anthroposols, and some examples are given in their paper.

Until more knowledge and experience is available, it is proposed not to formalise the classification of Anthroposols below the Suborder level. Acknowledgment is due to Fanning and Fanning (1989) for a number of the concepts and terminology used in this preliminary classification of Anthroposols.
Arenosols [RE]

[Pronounced Ah-ren-oh-sols or Ah-reen-oh-sols]

Concept

The core concept of this Order is "deep sandy soils".
It accommodates soils with predominantly sandy field textures (up to 10% clay content), and with no horizons containing more than 15% clay within the upper 1 m of the profile. It generally has no observable peds apart from some structural development in the A1 horizon. The upper 1 m of the soil profile can only contain relatively small amounts of coarse fragments or coarse, hard segregations and does not contain any hard layers such as pans or rock. Arenosols occur extensively in arid areas, the near coast zone and the south west, but are also present in many other parts of Australia. This Order incorporates the most widespread and abundant soils in Australia.

Definition

Other soils that have, within the upper 1.0 m of the soil profile:
1. a sandy field texture in 80% or more of the upper 1.0 m of the soil profile (i.e. a field texture of sand, loamy sand or clayey sand); and
2. no layer with a clay content that exceeds 15% (i.e. heavy sandy loam [SL+] or heavier); and
3. ≤10% (by visual abundance and weighted average) of coarse fragments and/or hard segregations >2 mm in size; and
4. no hard layers (cemented pans, other cemented materials, rock or saprock)

Comment

As B horizons are difficult to identify consistently in some Arenosols, specific mention of a B2 horizon is omitted from some Suborders. Arenosols will obviously grade to Kandosols and some difficulty may be experienced in separating them. Here Kandosols must have a clearly distinguishable, well-developed B2 horizon with more than 15% clay whereas Arenosols have less than 15% clay.

Reclassification may also be required for other sandy soils where deep examination below 1 m reveals deep clayey B horizons. See How to Classify for assistance with determining whether the layer is a B or D horizon. If the layer is a D horizon, the soil remains classified as an Arenosol.

Bleached or Grey Arenosols are distinguished from Podosols by the absence of Podosol diagnostic horizons. These horizons can occur below 1m deep and commonly at considerable depth. If no deep examination has been done in similar soils in similar environments, then the soil should classify as a Bleached or Grey Arenosol with a confidence level of 4. If evidence at a later date reveals the presence of Podosol diagnostic horizons at depth, the soil will need to be reclassified.

Some Arenosols may include one or more thin argic horizons (also termed lamellae) which are usually 5-10 mm thick.

Arenosols will also grade to Tenosols. This Third Edition of the Australian Soil Classification reflects a major change to the Tenosol Order. Many sandy soils previously classified as the colour-linked Orthic Suborders will now classify as Arenosols.

As the Arenosols Order includes soils with negligible development many deep sandy soils previously described as Rudosols will now classify as Arenosols.
This Third Edition of the Australian Soil Classification also reflects a significant change to the Calcarosol Order. Many sandy soils with pedogenic carbonates previously classified as Shelly, Calcic or Hypocalcic Calcarosols will now classify as Carbonatic or Calsilic Arenosols.

**Suborders**

- Soils that are not highly saline (EC <2 dSm⁻¹; 1:5 H₂O) and dominantly consist of sand-sized gypsum crystals. These crystals may not feel like sands when hand texturing due their dissolution in water.

  **Hypergypsic [FJ]**

- Soils that are highly saline (EC >2 dSm⁻¹; 1:5 H₂O), often salt-encrusted, frequently stratified, but do not have a permanent or seasonal water table and do not show any evidence, such as mottling, of episodic wetting by groundwater.

  **Hypersalic [CS]**

- Other soils with a peaty, humose, melacic or melanic horizon. A conspicuously bleached A2 horizon is not present.

  **Chernic [BE]**

- Soils that are calcareous throughout (at least the upper 1.0 m of the soil profile). The upper 0.1 m of the soil profile consists of dominantly fine-earth carbonate (visual estimate) and/or contains more than 40% (by analysis) of fine-earth carbonate.

  **Carbonatic [JT]**

- Other soils that are calcareous throughout (at least the upper 1.0 m of the soil profile), or calcareous at least directly below the A1 or Ap horizon or a depth of 0.2 m (whichever is the shallower).

  **Calsilic [JN]**

- Soils that consist dominantly of unconsolidated mineral materials that are distinct, not or only slightly gravelly (<10% >2 mm) sedimentary layers or buried soils but salinity is not high (EC<2 dSm⁻¹; 1:5 H₂O).

  **Stratic [ER]**

- Soils with a conspicuously bleached A2 horizon.

  **Bleached [GZ]**

Soils in which the dominant colour class in the major part of the upper 1 m of the solum is:

- Red.

  **Red [AA]**

- Brown.

  **Brown [AB]**

- Yellow.

  **Yellow [AC]**

- Grey.

  **Grey [AD]**
ARENOSOLS

Comment
The Hypersalic soils normally occur as gypsum lunettes and the Hypersalic soils are most common in many of the saline playas of the arid interior of the continent. The Chernic soils typically occur in low lying, wetter, cooler areas of southern Australia where organic matter accumulates in surface horizons. The Carbonatic and Calsilic soils occur on many coastal dunes with Calsilic soils also common in the mallee of southern Australia. The Bleached, Red, Brown, Yellow, Grey and Black soils mainly cater for the widespread siliceous dunes and sandsheets, as well as some coastal dunes. The Stratric soils occur where sands have been deposited through water action.

The Carbonatic soils are typically highly calcareous and dominated by sand-sized fine-earth carbonates throughout the profile. The Carbonatic Suborder in Arenosols partially replaces the former Shelly Suborder in Calcarosols which is now restricted to soils dominated by shell fragments in Rudosols.

The Calsilic Suborder includes sands that are calcareous throughout (with the possible exception of the surface) but are generally lower in carbonates and more siliceous than the Carbonatic Suborder.

The most commonly recorded Suborders are Carbonatic, Calsilic, Bleached, Red, Brown, Yellow, and Grey.

Great Groups
No Great Groups are presently proposed for the Hypersalic and Stratric Suborders as data are limited, plus the limited pedological development of these soils means that subsoils are generally only weakly developed.

Hypersalic Arenosols

• Soils in which sulfuric material (at least 0.15 m thick) occurs within the upper 1.5 m of the solum.

Sulfuric [EV]

Note that the Sulfuric Great Group can be replaced by the following Great Group where appropriate evidence is available.

• Soils in which both monosulfidic materials and sulfuric material (at least 0.15 m thick) occur within the upper 1.5 m of the solum.

Monosulfidic-Sulfuric [IW]

• Soils in which sulfidic materials occur within the upper 1.5 m of the solum.

Sulfidic [EU]

Note that the Sulfidic Great Group can be replaced by the following Great Groups where appropriate evidence is available.

• Soils in which both monosulfidic material and hypersulfidic material occur within the upper 1.5 m of the solum.

Monohypersulfidic [IX]

• Other soils in which hypersulfidic material occurs within the upper 1.5 m of the solum.
**ARENOSOLS**

**Hypersulfidic [IZ]**
- Soils in which both monosulfidic material and hyposulfidic material occur within the upper 1.5 m of the solum.

**Monohyposulfidic [JA]**
- Other soils with hyposulfidic material within the upper 1.5 m of the solum.

**Hyposulfidic [JC]**
- A gypsic horizon occurs within the upper 1 m of the solum.

**Gypsic [BZ]**
- The major part of the upper 0.5 m of the solum consists of materials dominated (>50%) by halite crystals.

**Halic [CC]**
- The major part of the upper 0.5 m of the solum consists of materials with <50% halite crystals.

**Subhalic [JK]**

**Chernic**
Suitable Great Groups may be found as listed for Bleached and coloured Arenosols

**Carbonatic and Calsilic Arenosols**
Note that not all Great Groups will be relevant for each Suborder.
- Soils that directly overlie a red-brown hardpan.
  **Duric [BJ]**
- Soils that directly overlie a calcrete pan.
  **Petrocalcic [DZ]**
- Soils with an argic horizon within the B horizon.
  **Argic [AP]**
- Soils that directly overlie hard rock.
  **Lithic [CZ]**
- Soils which directly overlie partially weathered or decomposed rock or saprolite.
  **Paralithic [DU]**
- Soils that directly overlie marl.
  **Marly [DD]**
- Soils that directly overlie unconsolidated mineral materials.
  **Regolithic [GF]**

**Chernic, Bleached, Red, Brown, Yellow, Grey and Black Arenosols**
- Soils that have a ferric horizon and overlie a red-brown hardpan.
  **Ferric-Duric [FK]**
Other soils that overlie a red-brown hardpan.

**Duric [BJ]**

Soils that contain a ferric horizon and which overlie ferricrete, a petroferric horizon or a petroreticulate horizon.

**Ferric-Petroferric [GE]**

Soils that overlie ferricrete, a petroferric horizon or a petroreticulate horizon.

**Petroferric [EA]**

Soils that overlie a hard siliceous pan.

**Silpanic [EM]**

Soils that overlie a hard calcrete pan.

**Petrocalcic [DZ]**

Soils that contain a ferric horizon and which overlie a reticulate horizon.

**Ferric-Reticulate [IS]**

Soils that overlie a reticulate horizon.

**Reticulate [EF]**

Soils with a ferric horizon.

**Ferric [BU]**

Soils with a bauxitic horizon.

**Bauxitic [AS]**

Soils with a manganic horizon.

**Manganic [DC]**

Soils that have andic properties and have formed in basaltic tephric materials that may be visibly stratified.

**Andic [AK]**

Soils that have formed in tephric materials that may be visibly stratified.

**Tephric [HF]**

Soils with an argic horizon.

**Argic [AP]**

Soils dominated by gritty coarse sand (0.2–2 mm) and, if present, fine gravel (particle size 2-6 mm). Gritty material composed of angular or subangular quartz or other hard rock fragments.

**Gritty [JQ]**

Soils with a tenic B horizon within the upper 1.0 m of the solum that has a sandy loam texture and a maximum of 15% clay. Kandic Arenosols have affinities with Kandosols but are too sandy.

**Kandic [JP]**
ARENOSOLS

- Soils with a tenic B horizon or a transitional horizon (C/B) occurring in fissures in the parent rock or saprolite that contains between 10 and 50% of B horizon material (including pedogenic carbonate).
  \[ \text{Inceptic [IA]} \]

- Soils that overlie hard rock.
  \[ \text{Lithic [CZ]} \]

- Soils that overlie partially weathered or decomposed rock or saprolite.
  \[ \text{Paralithic [DU]} \]

- Soils that overlie marl.
  \[ \text{Marly [DD]} \]

- Soils with a gypsic horizon in the upper 1 m of the solum.
  \[ \text{Gypsic [BZ]} \]

- The major part of the upper 1.5 m of the solum consists of visible heavy or opaque minerals (>3%) that may also be visibly stratified (identifiable by wet panning in the field).
  \[ \text{Gravic [JR]} \]

- Soils in which the fine-earth carbonate is evident only as a slight to moderate effervescence (1 M HCl), and/or contain less than 2% fine-earth carbonate, and have less than 20% hard carbonate nodules or concretions.
  \[ \text{Hypocalcic [CV]} \]

- Soils with a calcareous horizon containing more than 50% of hard calcrite fragments and/or carbonate nodules or concretions and/or carbonate-coated gravel.
  \[ \text{Lithocalcic [DA]} \]

- Soils with a calcareous horizon containing 20-50% of hard calcrite fragments and/or carbonate nodules or concretions and/or carbonate-coated gravel.
  \[ \text{Supracalcic [FB]} \]

- Soils with a calcareous horizon containing more than 20% of fine-earth carbonate, and 0–20% of hard calcrite fragments and/or carbonate nodules or concretions, and/or carbonate-coated gravel.
  \[ \text{Hypercalcic [CQ]} \]

- Other soils with a calcareous horizon containing fine-earth carbonate.
  \[ \text{Calcic [BD]} \]

- Soils that overlie unconsolidated mineral materials.
  \[ \text{Regolithic [GF]} \]

**Comment**

The calcareous classes above approximately correspond to those of Wetherby and Oades (1975) as follows: Hypocalcic - Class IV, Lithocalcic - Class III B and IIIC, Supracalcic - Class III B, Hypercalcic - Class III A, Calcic - Class 1 and IIIA. In the Lithocalcic and Supracalcic...
ARENOSOLS

classes the coarse fragments may be >0.2 m in size and soft carbonate may or may not be present.

Subgroups

No Subgroups are proposed for the Hypergypsic, Hypersalic, Carbonatic, Calsilic and Stratic Suborders.

Subgroups of Chernic, Bleached, Red, Brown, Yellow, Grey and Black Arenosols

- Soils with a peaty horizon.
  
  Peaty [DW]

- Soils with a humose horizon and the major part of the upper 1 m of the solum is strongly acid.
  
  Humose-Calcareous \(^1\) [GU]

- Soils with a humose horizon and at least some part of the upper 1 m of the solum is calcareous.
  
  Humose-Calcareous \(^2\) [FC]

- Other soils with a humose horizon.
  
  Humose [CK]

- Soils with a melacic horizon and the major part of the upper 1 m of the solum is not strongly acid.
  
  Melacic [DG]

- Other soils with a melacic horizon.
  
  Melacic [DG]

- Soils with a melanic horizon and the major part of the upper 1 m of the solum is strongly acid.
  
  Melanic-Calcareous [FC]

- Other soils with a melanic horizon.
  
  Melanic [DK]

- Soils with all the requirements for a peaty horizon except the thickness.
  
  Subpeaty [ID]

- Other soils in which the major part of the upper 1 m of the solum is strongly acid.
  
  Acidic [AI]

- Other soils in which at least some part of the upper 1 m of the solum is calcareous.

\(^1\) Note that the Humose-Calcareous subgroup is not required for the five calcic Great Groups.

\(^2\) Note that the Melanic-Calcareous subgroup is not required for the five calcic Great Groups.
Calcareous\(^3\) [BC]

- Other soils that are not strongly acid or calcareous.

Basic [AR]

**Family Criteria**

Use of the term A horizon may be inappropriate for some of these soils because of either minimal development due to an arid environment, or common surface deflation or accumulation caused by wind. Hence it is thought better to use the term surface soil for texture and to delete the thickness criteria. In general, surface soil in this context will probably be in the range of 0.1–0.2 m in thickness.

**Water repellence of surface soil**

- Non water repellent [NR]: Water absorbed in 10 seconds or less
- Water repellent [WR]: Water takes more than 10 seconds and 2 Molar ethanol takes 10 seconds or less to be absorbed into soil.
- Strongly water repellent [SR]: 2 Molar ethanol takes greater than 10 seconds or less to be absorbed into soil.

**Gravel of the surface and/or A1 horizon**

- Non-gravelly [E]: <2%
- Slightly gravelly [F]: 2–<10%
- Gravelly [G]: 10–<20%
- Moderately gravelly [H]: 20–50%
- Very gravelly [I]: >50%

**Surface soil texture**

- Peaty [J]: Dominated by organic materials
- Sandy [K]: S-LS-CS (up to 10% clay)
- Loamy [L]: SL-L (10–20% clay)

**Maximum texture below the surface or A1 (within the upper 1 m of the soil solum)**

- Sandy [K]: S-LS-CS (up to 10% clay)
- Loamy [L]: SL-L (10–20% clay)

**Soil depth**

- Deep [W]: 1.0–<1.5 m
- Very deep [X]: 1.5–5 m
- Giant [Y]: >5 m

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\(^3\) Note that the Calcareous subgroup is not required for the five calcic Great Groups.
CALCAROSOLS [CA]

[ Pronounced Cal-care-oh-sols ]

**Concept**

The soils in this Order are usually calcareous throughout the profile, often highly so. They constitute a widespread and important group of soils in southern Australia.

**Definition**

Soils that:

1. Are either calcareous throughout the solum - or calcareous at least directly below the A1 or Ap horizon, or a depth of 0.2 m (whichever is shallower). Carbonate accumulations must be judged to be pedogenic¹, i.e. are a result of soil forming processes in situ (either current or relict). Soils dominated by non-pedogenic calcareous materials such as particles of limestone or shells are excluded. See also calcrete, and

2. Do not have deep sandy profiles that have a field texture of sand, loamy sand or clayey sand in 80% or more of the upper 1.0 m.

**Comment**

A difficulty may arise in separating those Calcarosols that are not calcareous throughout from calcareous Kandosols and from Tenosols containing pedogenic carbonate. However, in the latter two soils it is usual for the carbonate to occur in the lower part of the B horizon, and not immediately below the A horizon. Even so, transitional cases will arise where it becomes a matter of judgement in to which order the particular soil is best placed. Similar transitions might occur between shallow Calcarosols and Arenic Rudosols overlying a layer of calcrete or limestone. Again, Calcareous Arenic Rudosols will occur where recent aeolian calcareous material has been deposited.

In landscapes dominated by wind-blown calcareous material it may be difficult to determine if the carbonates are pedogenic origin. Deep calcareous sands, which commonly occur in this situation, are now included in the Arenosols Order. Soils with minimal soil development and dominated by coarse particles of shells or other aquatic animals are included in Shelly Rudosols.

In dune landscapes, where these soils frequently occur, it is common to find evidence of post-European settlement deflation and layering of soil profiles caused by wind erosion and consequent deposition. Unless the surface depositional material is 0.3 m or more thick, it is ignored in the classification and treated as a phase. (see 'What do we classify?').

**Suborders**

- Soils that dominantly consist of gypsum crystals that are sand-sized or finer.
  
  **Hypergypsic [FJ]**

- Soils that are calcareous throughout. The upper 0.1 m of the solum consists of

¹ The carbonate is a result of soil-forming processes, in contrast to fragments of calcareous rock such as limestone. See also calcrete.
dominantly fine-earth carbonate (visual estimate) and/or contains more than 40% (by analysis) of fine-earth carbonate.

**Carbonatic [JT]**

- Soils in which the carbonate is evident only as a slight to moderate effervescence (1M HCl), and/or contain less than 2% fine-earth carbonate, and have less than 20% hard carbonate nodules or concretions.

**Hypocalcic [CV]**

- Soils with a calcareous horizon containing more than 50% of hard calcrete fragments and/or carbonate nodules or concretions and/or carbonate-coated gravel.

**Lithocalcic [DA]**

- Soils with a calcareous horizon containing 20-50% of hard calcrete fragments and/or carbonate nodules or concretions and/or carbonate-coated gravel.

**Supracalcic [FB]**

- Soils with a calcareous horizon containing more than 20% of mainly soft, finely divided carbonate, and 0-20% of hard calcrete fragments and/or carbonate nodules or concretions, and/or carbonate-coated gravel.

**Hypercalcic [CQ]**

- Other soils with a calcareous horizon. (See carbonate classes).

**Calcic [BD]**

**Comment**

The calcareous classes above approximately correspond to those of Wetherby and Oades (1975) as follows: Hypocalcic - Class IV, Lithocalcic - Class III B and IIIC, Supracalcic - Class III B, Hypercalcic - Class III A, Calcic - Class 1 and IIIA.

In the Lithocalcic and Supracalcic classes the coarse fragments may be >0.2 m in size and soft carbonate may or may not be present.

The Carbonatic Suborder partially replaces the former Shelly Suborder which is now restricted to soils dominated by shell fragments in Rudosols. The Carbonatic soils are typically highly calcareous and dominated by fine-earth carbonates throughout the profile.

Of the profiles classified, the Calcic and Hypercalcic Suborders are the most common.

**Great Groups**

**Hypergypsic Calcarosols**

Insufficient information is available to subdivide these soils further.

**Other Calcarosols**

Not all Great Groups will be relevant for every Suborder, for example, Rendic will be required only for the Hypercalcic Suborder.

- Soils that directly overlie a red-brown hardpan.

**Duric [BJ]**

- Soils that directly overlie a calcrete pan.

**Petrocalcic [DZ]**
• Soils in which the A horizon directly overlies a Bk horizon consisting almost entirely of soft carbonate (>80%).

  **Rendic [EE]**

• Soils with an argic horizon within the B horizon.

  **Argic [AP]**

• Soils in which the major part of the B horizon has a grade of structure that is stronger than weak.

  **Pedal [DY]**

• Soils that directly overlie hard rock.

  **Lithic [CZ]**

• Soils that directly overlie partially weathered or decomposed rock or saprolite.

  **Paralithic [DU]**

• Soils that directly overlie marl.

  **Marly [DD]**

• Soils that directly overlie unconsolidated mineral materials.

  **Regolithic [GF]**

**Subgroups**

Subgroups will not be applicable to all Great Groups of each Suborder, and not all Subgroups are mutually exclusive. The Supravescent and Hypervescent classes are not required for the Carbonatic Suborder. The Supravescent and Hypervescent classes may also be Epiphysodontic or Endophysodontic. However, the high content or absence of carbonate in the upper 0.1 m is thought to have more influence on land use than high sodicity. A number of soils have been recorded as having a conspicuously bleached A2 horizon. In many cases, however, this may be a reflection of high contents of fine-earth carbonate, hence this feature has not been used as a class differentia.

• Soils with a melanic horizon overlying a B horizon in which at least 0.3 m has vertic properties.

  **Melanic-Vertic [DN]**

• Other soils with a melanic horizon.

  **Melanic [DK]**

• Other soils with a B horizon in which at least 0.3 m has vertic properties.

  **Vertic [EX]**

• Soils in which the B horizon is strongly subplastic and the B or BC horizon contains a gypsic horizon.

  **Gypsic-Subplastic [FL]**

• Other soils with a strongly subplastic B horizon.

  **Subplastic [ET]**
• Other soils with a gypsic horizon within the B or BC horizon.  

**Gypsic [BZ]**

• Soils that are not calcareous in the A1 or Ap horizon, or to a depth of 0.2m if the A1 horizon is only weakly developed.

**Epibasic [IB]**

• Soils in which the upper 0.1 m of the solum consists of dominantly fine-earth carbonate (visual estimate), and/or contains more than 40% (by analysis) of fine-earth carbonate.

**Supravescent [HK]**

• Soils in which the upper 0.1 m of the solum consists of more than 20% fine-earth carbonate (visual estimate using a 10 x hand lens), and/or has a strong effervescence with 1 M HCl, and/or contains more than 8%\(^2\) (by analysis) of fine-earth carbonate.

**Hypervescent [CP]**

• Soils in which at least some subhorizon within the upper 0.5 m of the solum has an ESP of 15 or greater.

**Ephhypersodic [BR]**

• Soils in which an ESP of 15 or greater occurs in some subhorizon below 0.5 m.

**Endohypersodic [BP]**

• Other soils.

**Ceteric [IC]**

**Family Criteria**

Use of the term A horizon may be inappropriate for some of these soils because of either minimal development due to an arid environment, or common surface deflation or accumulation caused by wind. Hence it is thought better to use the term surface soil for texture and to delete the thickness criteria. In general, surface soil in this context will probably be in the range of 0.1–0.2 m in thickness. For the Calcarosols, a criterion is used to indicate the thickness above the upper boundary of the Bk horizon when present.

**Water repellence of surface soil**

<table>
<thead>
<tr>
<th>Type</th>
<th>Criterion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non water repellent</td>
<td>[NR]: Water absorbed in 10 seconds or less</td>
</tr>
<tr>
<td>Water repellent</td>
<td>[WR]: Water takes more than 10 seconds and 2 Molar ethanol takes 10 seconds or less to be absorbed into soil.</td>
</tr>
<tr>
<td>Strongly water repellent</td>
<td>[SR]: 2 Molar ethanol takes greater than 10 seconds or less to be absorbed into soil.</td>
</tr>
</tbody>
</table>

**Thickness of soil above upper boundary of Bk horizon (when present)**

<table>
<thead>
<tr>
<th>Type</th>
<th>Criterion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thin</td>
<td>[A]: &lt;0.1 m</td>
</tr>
<tr>
<td>Moderately thick</td>
<td>[B]: 0.1–&lt;0.3 m</td>
</tr>
<tr>
<td>Thick</td>
<td>[C]: 0.3–0.6 m</td>
</tr>
<tr>
<td>Very thick</td>
<td>[D]: &gt;0.6 m</td>
</tr>
</tbody>
</table>

\(^2\) Based on numerous fine-earth analyses by Primary Industries, South Australia.
Gravel of the surface and A1 horizon
Non-gravelly [E] : <2%
Slightly gravelly [F] : 2 -<10%
Gravelly [G] : 10–<20%
Moderately gravelly [H] : 20–50%
Very gravelly [I] >50%

Surface soil texture
Peaty [J] : Dominated by organic materials
Sandy [K] : S-LS-CS (up to 10% clay)
Loamy [L] : SL-L (10-20% clay)
Clay loamy [M] : SCL-CL (20-35% clay)
Silty [N] : ZL-ZCL (25-35% clay and silt 25% or more)
Clayey [O] : LC-MC-HC (more than 35% clay)

B horizon maximum texture\(^3\)
Sandy [K] : S-LS-CS (up to 10% clay)
Loamy [L] : SL-L (10-20% clay)
Clay loamy [M] : SCL-CL (20-35% clay)
Silty [N] : ZL-ZCL (25-35% clay and silt 25% or more)
Clayey [O] : LC-MC-HC (more than 35% clay)

Soil depth
Very shallow [T] : <0.25 m
Shallow [U] : 0.25–<0.5 m
Moderately deep [V] : 0.5–<1.0 m
Deep [W] : 1.0–<1.5 m
Very deep [X] : 1.5–5 m
Giant [Y] : >5 m

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\(^3\) This refers to the most clayey field texture category.
Chromosols [CH]

[Pronounced Chrome-oh-sols]

Concept
Soils with strong texture contrast between A horizons and B horizons. The latter are not strongly acid and are not sodic. The soils of this Order are among the most widespread soils used for agriculture in Australia, particularly those with red subsoils.

Definition
Soils other than Hydrosols with a clear or abrupt textural B horizon and in which the major part of the upper 0.2 m of the B2t horizon (or the major part of the entire B2t horizon if it is less than 0.2 m thick) is not sodic and not strongly acid. Soils with strongly subplastic upper B2t horizons are also included even if they are sodic.

Comment
In the case of those soils with strongly subplastic B horizons, care needs to be taken to ensure if they qualify for the clear or abrupt textural B horizon. As far as is presently known, such soils appear to be largely confined to the Riverine Plain of south eastern Australia.

Suborders
The dominant colour class in the major part of the upper 0.2 m of the B2t horizon (or the major part of the entire B2t horizon if it is less than 0.2 m thick) is:

- Red
  - Red [AA]

- Brown
  - Brown [AB]

- Yellow
  - Yellow [AC]

- Grey
  - Grey [AD]

- Black
  - Black [AE]

Comment
The Red and Brown Suborders account for the majority of the profiles classified.

Great Groups
These will vary somewhat among the various colour class Suborders, but it is likely that the subdivision given below will apply to most.
• Soils with a red-brown hardpan either within or directly underlying the B horizon.

**Duric [BJ]**

• Soils with a petroferric horizon within the solum.

**Petroferric [EA]**

• Soils with a B horizon that is not calcareous and which directly overlies a calcrete pan.

**Petrocalcic [DZ]**

• Soils in which the upper 0.2 m of the B2t horizon (or the B2t horizon if it is less than 0.2 m thick) has a strong blocky or polyhedral structure in which average ped size is usually in the range of 5–20 mm. There is very weak adhesion between peds (when dry it is very easy to insert a spade into the upper B2t horizon). Salt contents are usually high, resulting in weak dry strength and a bulk density of about 1.3 t m\(^{-3}\) or less. In some soils the B2t horizon may be weakly subplastic. A common feature (but not diagnostic) of the overlying A horizons is the presence of a band of vesicular pores near the surface or on the underside of any surface flake.

**Pedaric [BK]**

• Soils in which the major part of the B2t horizon is strongly subplastic.

**Subplastic [ET]**

• Soils with an exchangeable Ca/Mg ratio of less than 0.1 in the major part of the B2t horizon.

**Magnesic [DB]**

• Soils in which the major part of the B2t horizon is dystrophic.

**Dystrophic [AF]**

• Soils in which the major part of the B2t horizon is mesotrophic.

**Mesotrophic [AG]**

• Soils in which the major part of the B2t horizon is eutrophic but the B and BC horizons are not calcareous.

**Eutrophic [AH]**

• Soils in which the carbonate is evident only as a slight to moderate effervescence (1M HCl), and/or contain less than 2% soft finely divided carbonate, and have less than 20% hard carbonate nodules or concretions.

**Hypocalcic [CV]**

• Soils with a calcareous horizon containing more than 50% of hard calcrete fragments and/or carbonate nodules or concretions and/or carbonate-coated gravel.

**Lithocalcic [DA]**

• Soils with a calcareous horizon containing 20-50% of hard calcrete fragments and/or carbonate nodules or concretions and/or carbonate-coated gravel.

**Supracalcic [FB]**

• Soils with a calcareous horizon containing more than 20% of mainly soft, finely divided carbonate, and 0-20% of hard calcrete fragments and/or carbonate nodules or
concretions, and/or carbonate-coated gravel.

- **Hypercalcic** [CQ]

- Other soils with a calcareous horizon. (See carbonate classes).

- **Calcic** [BD]

**Comment**

The calcareous classes above approximately correspond to those of Wetherby and Oades (1975) as follows: Hypocalcic - Class IV, Lithocalcic - Class III B and IIIC, Supracalcic - Class III B, Hypercalcic - Class III A, Calcic - Class 1 and IIIA. In the Lithocalcic and Supracalcic classes the coarse fragments may be >0.2 m in size and soft carbonate may or may not be present.

Of the profiles classified, the Calcic class was found to be most common in soils with a calcareous horizon. However, almost half of the Chromosol Great Groups classified were Eutrophic. The Duric and Pedaric soils are virtually confined to the arid zone, the former being particularly widespread in Western Australia and the latter in western Queensland and New South Wales, and in South Australia.

**Subgroups**

The Subgroups listed below may not all be relevant for every Great Group of every Suborder:

- Soils with a peaty horizon.

- **Peaty** [DW]

- Soils with a humose horizon and a conspicuously bleached A2 horizon.

- **Humose-Bleached** [EY]

- Soils with a humose horizon and the major part of the B2t horizon is mottled.

- **Humose-Mottled** [CM]

- Other soils with a humose horizon.

- **Humose** [CK]

- Soils with a melacic horizon and the major part of the B2t horizon is mottled.

- **Melacic-Mottled** [DI]

- Other soils with a melacic horizon.

- **Melacic** [DG]

- Soils with a melanic horizon and a B horizon in which at least 0.3 m has vertic properties.

- **Melanic-Vertic** [DN]

- Soils with a melanic horizon and the major part of the B2t horizon is mottled.

- **Melanic-Mottled** [DM]

- Other soils with a melanic horizon.

- **Melanic** [DK]
- Soils with a conspicuously bleached A2 horizon overlying a B horizon in which at least 0.3m has vertic properties.
  **Bleached-Vertic [BB]**
- Other soils with a B horizon in which at least 0.3 m has vertic properties.
  **Vertic [EX]**
- Soils with a gypsic horizon within the B or BC horizon.
  **Gypsic [BZ]**
- Soils with a ferric horizon within the solum, and at least the lower part of the B horizon is sodic.
  **Ferric-Sodic [HC]**
- Soils with a conspicuously bleached A2 horizon and a ferric horizon within the solum.
  **Bleached-Ferric [AV]**
- Other soils with a ferric horizon within the solum.
  **Ferric [BU]**
- Soils with a conspicuously bleached A2 horizon and a manganic horizon within the solum.
  **Bleached-Manganic [AY]**
- Other soils with a manganic horizon within the solum.
  **Manganic [DC]**
- Soils with fine-earth effervescence (1M HCl) throughout the solum.
  **Effervescent [IE]**
- Soils with a conspicuously bleached A2 horizon and a B horizon in which at least the lower part is sodic.
  **Bleached-Sodic [BA]**
- Soils in which the major part of the B2t horizon is mottled, and at least the lower part of the B horizon is sodic.
  **Mottled-Sodic [HB]**
- Other soils with a B horizon in which at least the lower part is sodic.
  **Sodic [EO]**
- Soils with a conspicuously bleached A2 horizon and the major part of the B2t horizon is mottled.
  **Bleached-Mottled [AZ]**
- Other soils with a conspicuously bleached A2 horizon.
  **Bleached [AT]**
- Soils with a reticulate horizon below the B2t horizon.  
  **Reticulate [EF]**

- Other soils in which the major part of the B2t horizon is mottled.  
  **Mottled [DQ]**

- Other soils in which the major part of the B2t horizon is whole coloured.  
  **Haplic [CD]**

**Comment**

A large proportion of the profiles classified so far have a Haplic Subgroup. This would suggest that the class may need to be further subdivided, but it is difficult to find suitable criteria to base this on. The presence of a pale (unbleached) A2 horizon could be used, but the significance of this is uncertain. A subdivision could be made between soils with clear or abrupt textural changes if this was thought to be of importance. Similarly, a distinction between structured and massive B2t horizons could be made.

Possible changes such as these can easily be introduced if evidence is produced to justify their use.

**Family Criteria**

**Water repellence of surface soil**

Non water repellent  \[\text{NR}\] : Water absorbed in 10 seconds or less  
Water repellent  \[\text{WR}\] : Water takes more than 10 seconds and 2 Molar ethanol takes 10 seconds or less to be absorbed into soil.  
Strongly water repellent  \[\text{SR}\] : 2 Molar ethanol takes greater than 10 seconds or less to be absorbed into soil.

**A horizon thickness, or thickness of organic horizon (O2, P1 or P2) if present**

Thin  \[\text{A}\] : <0.1 m  
Moderately thick  \[\text{B}\] : 0.1–<0.3 m  
Thick  \[\text{C}\] : 0.3–0.6 m  
Very thick  \[\text{D}\] : >0.6 m

**Gravel of the surface and A1 horizon**

Non-gravelly  \[\text{E}\] : <2%  
Slightly gravelly  \[\text{F}\] : 2–<10%  
Gravelly  \[\text{G}\] : 10–<20%  
Moderately gravelly  \[\text{H}\] : 20–50%  
Very gravelly  \[\text{I}\] : >50%

**A1 horizon texture, or texture of organic horizon (O2, P1 or P2) if present**

Peaty  \[\text{J}\] : Dominated by organic materials  
Sandy  \[\text{K}\] : S-LS-CS (up to 10% clay)  
Loamy  \[\text{L}\] : SL-L (10-20% clay)  
Clay loamy  \[\text{M}\] : SCL-CL (20-35% clay)  
Silty  \[\text{N}\] : ZL-ZCL (25-35% clay and silt 25% or more)  
Clayey  \[\text{O}\] : LC-MC-HC (>35% clay)
### B horizon maximum texture

- **Clay loamy** \([M]\) : SCL-CL (20-35% clay)
- **Silty** \([N]\) : ZL-ZCL (25-35% clay and silt 25% or more)
- **Clayey** \([O]\) : LC - MC - HC (greater than 35% clay)

### Soil depth

- **Very shallow** \([T]\) : <0.25 m
- **Shallow** \([U]\) : 0.25–<0.5 m
- **Moderately deep** \([V]\) : 0.5–<1.0 m
- **Deep** \([W]\) : 1.0–<1.5 m
- **Very deep** \([X]\) : 1.5–5 m
- **Giant** \([Y]\) : >5 m

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1 This refers to the most clayey field texture category.
Dermosols [DE]

[Pronounced Derm-oh-sols]

**Concept**
Soils with structured B2 horizons and lacking strong texture-contrast between A and B horizons. Although there is some diversity within the Order, it brings together a range of soils with some important properties in common.

**Definition**
Soils other than Vertosols, Hydrosols, Calcarosols and Ferrosols that:
1. Have B2 horizons that have grade of pedality greater than weak\(^1\) throughout the major part of the horizon, and
2. Do not have clear or abrupt textural B horizon.

**Comment**
Some clayey soils in the arid zone which are relatively high in salt tend to have strong, fine blocky structure. It may be difficult to decide if they are Vertosols or Dermosols because of an apparent lack of cracking and slickensides or lenticular peds. The use of shrinkage measurements such as those discussed under vertic properties will help to resolve this situation.

It is common experience that pedologists are inclined to use the phrase 'weak to moderate' when they are in doubt as to the grade of the structure. If such a designation is used it will result in the soil being classed as a Dermosol.

**Suborders**
The dominant colour class in the major part of the upper 0.5 m of the B2 horizon (or the major part of the entire B2 horizon if it is less than 0.5 m thick) is:

- Red.

- Brown.

- Yellow.

- Grey.

- Black.

\(^1\) It is common experience that pedologists are inclined to use the phrase 'weak to moderate' when they are in doubt as to the grade of structure. If such a designation is used it will result in the soil being classed as a Dermosol.
Comment

The upper 0.5 m of the B2 horizon is used as the diagnostic section for colour in Dermosols, Ferrosols and Kandosols because of the often indistinct A-B horizon boundaries in these soils compared with those in Chromosols, Kurosols and Sodosols.

Great Groups

It is thought that the Great Group classes listed below will be appropriate for most of the various colour Suborders, although yellow and grey forms are relatively uncommon.

- Soils with a red-brown hardpan either within or directly underlying the B horizon.
  Duric [BJ]

- Soils with a B horizon either containing or directly underlain by ferricrete, a petroferric horizon, or a petroreticulate horizon.
  Petroferric [EA]

- Soils with a B horizon that is not calcareous and which directly overlies a calcrete pan.
  Petrocalcic [DZ]

- Soils in which the upper 0.2 m of the B2 horizon (or the B2 horizon if it is less than 0.2 m thick) has a strong blocky or polyhedral structure in which average ped size is usually in the range of 5-20 mm. There is very weak adhesion between peds (when dry it is very easy to insert a spade into the upper B2 horizon). Salt contents are usually high, resulting in weak dry strength and a bulk density of about 1.3 t m$^{-3}$ less. In some soils the B2 horizons may be weakly subplastic. A common feature (but not diagnostic) of the overlying A horizons is the presence of a band of vesicular pores near the surface or on the underside of any surface flake.
  Pedaric [BK]

- Soils in which the major part of the B2 horizon is strongly subplastic.
  Subplastic [ET]

- Soils with an exchangeable Ca/Mg ratio of less than 0.1 in the major part of the B2 horizon.
  Magnesic [DB]

- Soils in which the major part of the B2 horizon is dystrophic.
  Dystrophic [AF]

- Soils in which the major part of the B2 horizon is mesotrophic.
  Mesotrophic [AG]

- Soils in which the major part of the B2 horizon is eutrophic but the B and BC horizons are not calcareous.
  Eutrophic [AH]

- Soils in which the carbonate is evident only as a slight to moderate effervescence (1 M HCl), and/or contain less than 2% soft finely divided carbonate, and have less than 20% hard carbonate nodules or concretions.
  Hypocalcic [CV]
• Soils with a calcareous horizon containing more than 50% of hard calcrete fragments and/or carbonate nodules or concretions and/or carbonate-coated gravel.

**Lithocalcic [DA]**

• Soils with a calcareous horizon containing 20-50% of hard calcrete fragments and/or carbonate nodules or concretions and/or carbonate-coated gravel.

**Supracalcic [FB]**

• Soils with a calcareous horizon containing more than 20% of mainly soft, finely divided carbonate, and 0-20% of hard calcrete fragments and/or carbonate nodules or concretions, and/or carbonate-coated gravel.

**Hypercalcic [CQ]**

• Other soils with a calcareous horizon. (See carbonate classes).

**Calcic [BD]**

**Comment**

The calcareous classes above approximately correspond to those of Wetherby and Oades (1975) as follows: Hypocalcic - Class IV, Lithocalcic - Class III B and III C, Supracalcic - Class III B, Hypercalcic - Class III A, Calcic - Class I and IIIA. In the Lithocalcic and Supracalcic classes the coarse fragments may be >0.2 m in size and soft carbonate may or may not be present.

Of the profiles classified, the Eutrophic class was the most common Great Group. The Duric and Pedaric soils are virtually confined to the arid zone, the former being particularly widespread in Western Australia and the latter in western Queensland and New South Wales, and in South Australia.

**Subgroups**

It is thought that the following Subgroups will cater for most situations, although obviously some will not be relevant for particular Great Groups.

• Soils with a humose horizon and the major part of the B2 horizon is mottled.

**Humose-Mottled [CM]**

• Soils with a humose horizon and the major part of the B2 horizon is strongly acid.

**Humose-Acidic [GY]**

• Other soils with a humose horizon.

**Humose [CK]**

• Soils with a melacic horizon and a reticulate horizon that occurs below the B2 horizon.

**Melacic-Reticulate [GC]**

• Soils with a melacic horizon and the major part of the B2 horizon is mottled.

**Melacic-Mottled [DI]**

• Other soils with a melacic horizon.

**Melacic [DG]**
• Soils with a melanic horizon and a B horizon in which at least 0.3 m has vertic properties.

Melanic-Vertic [DN]

• Soils with a melanic horizon and the major part of the B2 horizon is mottled.

Melanic-Mottled [DM]

• Soils with a melanic horizon and the major part of the B2 horizon is strongly acid.

Melanic-Acidic [FV]

• Soils with a melanic horizon and a B horizon in which at least the lower part is sodic.

Melanic-Sodic [HA]

• Other soils with a melanic horizon.

Melanic [DK]

• Soils with a conspicuously bleached A2 horizon and a B horizon in which at least 0.3m has vertic properties.

Bleached-Vertic [BB]

• Other soils with a B horizon in which at least 0.3 m has vertic properties.

Vertic [EX]

• Soils with a gypsic horizon within the B or BC horizon.

Gypsic [BZ]

• Soils with a ferric horizon within the solum and a B2 horizon in which the major part is strongly acid.

Ferric-Acidic [GW]

• Soils with a ferric horizon within the solum and a B horizon in which at least the lower part is sodic.

Ferric-Sodic [HC]

• Soils with a conspicuously bleached A2 horizon and a ferric horizon within the solum.

Bleached-Ferric [AV]

• Other soils with a ferric horizon within the solum.

Ferric [BU]

• Soils with a manganic horizon within the solum and a B2 horizon in which the major part is strongly acid.

Manganic-Acidic [GX]

• Soils with a conspicuously bleached A2 horizon and a manganic horizon within the solum.

Bleached-Manganic [AY]

• Other soils with a manganic horizon within the solum.
Manganic [DC]
- Soils in which the major part of the B2 horizon is strongly acid and at least the lower part is sodic.

Acidic-Sodic [HO]
- Soils with a conspicuously bleached A2 horizon and a B2 horizon in which the major part is strongly acid.

Bleached-Acidic [AU]
- Soils in which the major part of the B2 horizon is strongly acid and mottled.

Acidic-Mottled [AJ]
- Other soils with a B2 horizon in which the major part is strongly acid.

Acidic [AI]
- Soils with a conspicuously bleached A2 horizon and a B horizon in which at least the lower part is sodic.

Bleached-Sodic [BA]
- Soils in which the major part of the B2 horizon is mottled and at least the lower part of the B horizon is sodic.

Mottled-Sodic [HB]
- Other soils with a B horizon in which at least the lower part is sodic.

Sodic [EO]
- Soils with a conspicuously bleached A2 horizon and the major part of the B2 horizon is mottled.

Bleached-Mottled [AZ]
- Other soils with a conspicuously bleached A2 horizon.

Bleached [AT]
- Soils with a reticulate horizon below the B2 horizon.

Reticulate [EF]
- Other soils in which the major part of the B2 horizon is mottled.

Mottled [DQ]
- Other soils in which the major part of the B2 horizon is whole coloured.

Haplic [CD]

Comment
In some dystrophic Dermosols there can be a problem with the definition of Sodic Subgroups because of their low base status (see ESP). No provision is made for Acidic Subgroups for soils with melacic horizons as these are most likely to always have acid B2 horizons. Similarly, Acidic Subgroups are unlikely to be required for the Dystrophic Great Groups as most such soils will be acid, whereas the Eutrophic Great Groups are unlikely to be acid. A number of classes are not mutually exclusive, thus many Vertic Subgroups are probably also...
Sodic or Bleached-Sodic. It is not possible to cater for all such combinations. Of the profiles classified to date many are Haplic, indicating a possible need for further subdivision.

### Family Criteria

#### A1 horizon thickness, or thickness of organic horizon (O2, P1 or P2) if present

<table>
<thead>
<tr>
<th>Thickness</th>
<th>Code</th>
<th>Thickness Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thin</td>
<td>[A]</td>
<td>&lt;0.1 m</td>
</tr>
<tr>
<td>Moderately thick</td>
<td>[B]</td>
<td>0.1–&lt;0.3 m</td>
</tr>
<tr>
<td>Thick</td>
<td>[C]</td>
<td>0.3–0.6 m</td>
</tr>
<tr>
<td>Very thick</td>
<td>[D]</td>
<td>&gt;0.6 m</td>
</tr>
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</table>

#### Gravel of the surface and A1 horizon

<table>
<thead>
<tr>
<th>Gravel texture</th>
<th>Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non-gravelly</td>
<td>[E]</td>
<td>&lt;2%</td>
</tr>
<tr>
<td>Slightly gravelly</td>
<td>[F]</td>
<td>2–&lt;10%</td>
</tr>
<tr>
<td>Gravelly</td>
<td>[G]</td>
<td>10–&lt;20%</td>
</tr>
<tr>
<td>Moderately gravelly</td>
<td>[H]</td>
<td>20–50%</td>
</tr>
<tr>
<td>Very gravelly</td>
<td>[I]</td>
<td>&gt;50%</td>
</tr>
</tbody>
</table>

#### A1 horizon texture, or texture of organic horizon (O2, P1 or P2) if present

<table>
<thead>
<tr>
<th>Texture</th>
<th>Code</th>
<th>Description</th>
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</thead>
<tbody>
<tr>
<td>Peaty</td>
<td>[J]</td>
<td>Dominated by organic materials</td>
</tr>
<tr>
<td>Sandy</td>
<td>[K]</td>
<td>S-LS-CS (up to 10% clay)</td>
</tr>
<tr>
<td>Loamy</td>
<td>[L]</td>
<td>SL-L (10-20% clay)</td>
</tr>
<tr>
<td>Clay loamy</td>
<td>[M]</td>
<td>SCL-CL (20-35% clay)</td>
</tr>
<tr>
<td>Silty</td>
<td>[N]</td>
<td>ZL-ZCL (25-35% clay and silt 25% or more)</td>
</tr>
<tr>
<td>Clayey</td>
<td>[O]</td>
<td>LC-MC-HC (&gt;35% clay)</td>
</tr>
</tbody>
</table>

#### B horizon maximum texture

<table>
<thead>
<tr>
<th>Texture</th>
<th>Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sandy</td>
<td>[K]</td>
<td>S-LS-CS (up to 10% clay)</td>
</tr>
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<td>Silty</td>
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<td>ZL-ZCL (25-35% clay and silt 25% or more)</td>
</tr>
<tr>
<td>Clayey</td>
<td>[O]</td>
<td>LC-MC-HC (more than 35% clay)</td>
</tr>
</tbody>
</table>

#### Soil depth

<table>
<thead>
<tr>
<th>Depth</th>
<th>Code</th>
<th>Depth Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very shallow</td>
<td>[T]</td>
<td>&lt;0.25 m</td>
</tr>
<tr>
<td>Shallow</td>
<td>[U]</td>
<td>0.25–&lt;0.5 m</td>
</tr>
<tr>
<td>Moderately deep</td>
<td>[V]</td>
<td>0.5–&lt;1.0 m</td>
</tr>
<tr>
<td>Deep</td>
<td>[W]</td>
<td>1.0–&lt;1.5 m</td>
</tr>
<tr>
<td>Very deep</td>
<td>[X]</td>
<td>1.5–5 m</td>
</tr>
<tr>
<td>Giant</td>
<td>[Y]</td>
<td>&gt;5 m</td>
</tr>
</tbody>
</table>

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2 This refers to the most clayey field texture category.
Ferrosols [FE]

[Pronounced Fare-oh-sols]

Concept
Soils with B2 horizons that are high in free iron oxide and lack strong texture-contrast between A and B horizons.

Definition
Soils other than Vertosols, Hydrosols, and Calcarosols that:
1. Have B2 horizons in which the major part has a free iron oxide content greater than 5% Fe in the fine-earth fraction (<2 mm), and
2. Do not have a clear or abrupt textural B horizon or a B2 horizon in which at least 0.3 m has vertic properties.

Comment
These soils are almost entirely formed on either mafic or ultramafic igneous rocks, their metamorphic equivalents, or alluvium derived therefrom. Although these soils do not occupy large areas in Australia, they are widely recognised and often intensively used because of their favourable physical properties. The most common forms have B2 horizons with a strong grade of pedality; such horizons typically have polyhedral compound peds up to 10-15 mm, usually with smooth and often shiny faces, which break down readily to primary peds about 5 mm or less in size. However forms also occur with a very fine granular structure which may appear massive in place. Horizons are usually high in clay and subplastic.

Suborders
The dominant colour class in the major part of the upper 0.5 m of the B2 horizon (or the major part of the entire B2 horizon if it is less than 0.5 m thick) is:

- Red. Red [AA]
- Brown. Brown [AB]
- Yellow. Yellow [AC]
- Grey. Grey [AD]
- Black. Black [AE]
Great Groups

It is thought that the Great Group classes listed below will be appropriate for each colour Suborder. Red and Brown are by far the most common colour classes. Of the Great Groups listed below, the Calcareous and Magnesic classes are relatively uncommon.

- Soils with an exchangeable Ca/Mg ratio of less than 0.1 in the major part of the B2 horizon.

  **Magnesic [DB]**

- Soils in which the major part of the B2 horizon is dystrophic.

  **Dystrophic [AF]**

- Soils in which the major part of the B2 horizon is mesotrophic.

  **Mesotrophic [AG]**

- Soils in which the major part of the B2 horizon is eutrophic but the B and BC horizons are not calcareous.

  **Eutrophic [AH]**

- Soils in which at least some part of the B or the BC horizon is calcareous.

  **Calcareous [BC]**

Subgroups

It is thought that the following Subgroups will cater for most situations, although obviously some will not be relevant for particular Great Groups.

Soils with an A horizon having a very fine granular structure (<2 mm) and a dry consistence strength that is weak to very weak. The horizon usually has a low bulk density and may be water repellent.

  **Snuffy [EN]**

- Soils with a humose horizon and the major part of the B2 horizon is strongly acid.

  **Humose-Acidic [GY]**

- Other soils with a humose horizon.

  **Humose [CK]**

- Soils with a melacic horizon.

  **Melacic [DG]**

- Soils with a melanic horizon and the major part of the B2 horizon is mottled.

  **Melanic-Mottled [DM]**

- Soils with a melanic horizon and the major part of the B2 horizon is strongly acid.

  **Melanic-Acidic [FV]**

- Other soils with a melanic horizon.

  **Melanic [DK]**
• Soils with a ferric horizon within the solum and a B2 horizon in which the major part is strongly acid.

**Ferric-Acidic [GW]**

• Other soils with a ferric horizon within the solum.

**Ferric [BU]**

• Soils with a manganic horizon within the solum.

**Manganic [DC]**

• Other soils with a B2 horizon in which the major part is strongly acid.

**Acidic [AI]**

• Soils with a B2 horizon in which at least the lower part is sodic.

**Sodic [EO]**

• Other soils in which the major part of the B2 horizon is mottled.

**Mottled [DQ]**

• Other soils in which the major part of the B2 horizon is whole coloured.

**Haplic [CD]**

**Comment**

The Haplic Subgroup is the most common in the Ferrosols classified to date, followed by Acidic with the remaining Subgroups fairly evenly distributed. All Haplic soils have been further examined, but apart from possibly using structure there seem to be few other differentiae that could be used for further subdivision.

**Family Criteria**

**A1 horizon thickness, or thickness of organic horizon (O2, P1 or P2) if present**

- Thin
  - [A] : <0.1 m
- Moderately thick
  - [B] : 0.1–<0.3 m
- Thick
  - [C] : 0.3–0.6 m
- Very thick
  - [D] : >0.6 m

**Gravel of the surface and A1 horizon**

- Non-gravelly
  - [E] : <2%
- Slightly gravelly
  - [F] : 2–<10%
- Gravelly
  - [G] : 10–<20%
- Moderately gravelly
  - [H] : 20–50%
- Very gravelly
  - [I] : >50%
A1 horizon texture, or texture of organic horizon (O2, P1 or P2) if present

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</table>

B horizon maximum texture\(^1\)

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<td>[O]</td>
<td>LC - MC - HC (greater than 35% clay)</td>
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</table>

Soil depth

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</table>

\(^1\) This refers to the most clayey field texture category.
Hydrosols [HY]

[ Pronounced Hi-dro-sols ]

Concept

This Order is designed to accommodate a range of seasonally or permanently wet soils and thus there is some diversity within the Order. The key criterion is saturation of the major part of the soil profile for prolonged periods (2-3 months) in most years. The soils may or may not experience reducing conditions for all or part of the period of saturation, and thus manifestations of reduction and oxidation such as gley colours and ochrous mottles may or may not be present.

Saturation by a water table may not necessarily be caused by low soil permeability. Often site drainage will be the most important factor, while in other well-known cases tidal influence is dominant. The relevant Field Handbook drainage classes are very poorly and poorly drained.

Several major classes of soils are excluded because it is considered their other profile characteristics are of greater significance than wetness. These are the Organosols, Podosols and Vertosols. Although some Hydrosols are dominated by organic materials (see Intertidal Hydrosols below), it is thought that because of their unique nature (i.e. largely consisting of mangrove debris that is regularly inundated by saline tidal waters), it is more appropriate to classify them as organic Hydrosols rather than as a class of Organosols that occur in a mangrove environment.

Definition

Soils other than Organosols, Podosols and Vertosols in which the major part of the soil profile is saturated for at least 2-3 months in most years.

Comment

The approach taken in this concept of 'wet' soils differs from more traditional usage in that reducing conditions are not emphasised. The rationale for the present approach is based on the assumption that saturation affects soil properties irrespective of whether or not reducing conditions are present. Obvious examples are those relating to certain physical and engineering properties, which result in limitations to the use of a soil e.g. trafficability, etc.

A further reason for not making reducing conditions mandatory is the well-known difficulty in identifying such conditions, which are often of a temporal nature and sporadic in spatial distribution. It is widely recognised that the traditional use of gley colours and particular kinds of mottling are not universally indicative of a saturated condition or its duration. In particular, mottles or other segregations can be relict. Another problem in identification of reducing conditions, is the experience that various indicator dyes such as a,a-dipyridyl (Childs & Clayden 1986) may be unreliable.

It will also be apparent that the concept adopted for Hydrosols will normally exclude the pseudo (or surface water) gley class commonly distinguished in several European classification schemes. These soils have a perched water table usually caused by a slowly permeable horizon or layer within the soil profile.

A difficult question arises as to how artificially drained soils are best treated. In many cases drainage will merely lower the water table to depths which permit the successful growth of particular plants. Such depths may still be relatively shallow e.g. 0.5–1 m, and capillary rise may result in wet soil conditions to variable heights above the new water table. Additionally, the topographic situation and/or the climatic environment may mean that drainage merely
HYDROSOLS

reduces the period of saturation. If drainage is such that saturation no longer occurs for appropriate periods in the relevant parts of the profile, the soil can strictly no longer be considered a Hydrosol. Possibly a 'drained' phase may be appropriate in some such circumstances.

In the case of irrigated soils, the main example is when more or less permanent flood irrigation is employed to grow rice. This would be expected to change, for example, a Chromosol to a Chromosolic Hydrosol. It should be noted that the definition of the Order is deliberately somewhat equivocal in that the duration and frequency of saturation of a precise section of the profile are not specifically defined. Lack of water table data is one reason, but it is also thought that a degree of flexibility is required for the definition. It is recognised that the extent of soil wetness can seldom be assessed by a single inspection of a particular site. However, in the author’s experience judicious questioning of people with local knowledge, together with the soil scientist’s assessment of soil and site drainage and climatic environment, can usually achieve a satisfactory resolution of the problem.

Suborders

- Soils of tidal estuaries, bays and river deltas that experience permanent inundation between Mean Low Water Springs (MLWS) and 2.5 m below MLWS.

  **Subtidal [IU]**

- Soils of inland water bodies that are located between the water surface and 2.5 m below the surface.

  **Subaqueous [IV]**

- Soils of intertidal flats (often colonised by mangroves) that experience regular saline tidal inundation of mostly high frequency.

  **Intertidal [CW]**

- Soils of supratidal flats (normally bare of vegetation except for halophytes such as samphires), often salt-encrusted. Tidal inundation is infrequent (spring tides) but a saline water table is present at shallow depths.

  **Supratidal [EW]**

- Soils of the extratidal zone (usually supporting grassland). Tidal inundation is infrequent and achieved only by exceptional storm or cyclonic tides (above high spring tides). Freshwater inundation is seasonally common.

  **Extratidal [BT]**

- Soils of the saline playa lakes (including coastal salinas and continental playas) which are usually bare and when dry are frequently halite- or gypsum-encrusted, or with a sparse cover of halophytes such as samphires. The continental playas are infrequently inundated with fresh water, but a shallow saline ground water table is usually present in all types throughout the year, mostly within 50 cm of the surface.

  **Hypersalic [CS]**

- Salinised soils caused by a rising saline water table or by saline seepage resulting from near-surface lateral movement (through flow) of water and salt from higher landscape positions. Such areas may be bare and salt-encrusted, often have a soft fluffy surface, and may or may not have a sparse cover of halophytic plants. Water table conductivity will usually be in the range of 2–50 dSm⁻¹; soil salinity may vary widely due to capillary concentration at or near the surface, and subsequent leaching of salt by seasonal precipitation.
HYDROSOLS

**Salic [EG]**

Other soils with a seasonal or permanent water table and in which the major part of the soil profile (or the subsoil if the profile is stratified) is mottled.

**Redoxic [ED]**

Other soils with a seasonal or permanent water table and in which the major part of the soil profile (or the subsoil if the profile is stratified) is whole coloured.

**Oxyaquic [DT]**

**Comment**

The features used in the definitions of the first seven Suborders differ from those used elsewhere in the classification in that the classes are essentially based on the frequency of tidal or freshwater inundation and the nature of the soil surface. This is thought to be an appropriate approach as the key feature of Hydrosols is their wetness. The references in parenthesis to vegetation in the definitions are merely indicating accessory properties of the class which may aid identification of what are essentially wetness criteria, for example, the presence of certain mangrove species will normally indicate a regular frequency of tidal wetting. Although it may be difficult to identify the Extratidal Suborder by the low frequency of tidal inundation, there is usually a distinct boundary between this zone and the often bare, salt-encrusted Supratidal zone. This boundary is commonly marked by a low (0.1–0.2 m) ‘scarp’. The three tidal-affected Suborders are largely based on data from Cook and Mayo (1977).

For the purposes of soil classification, hydrosols located within Intermittently Closed and Open Lakes and Lagoons (ICOLLS) are considered to be tidal. Where inundation at the perimeter of larger water bodies is cyclical as a result of seiches or from variability in rainfall and runoff, it is often difficult to decide if currently submerged soils are either Subaqueous, Redoxic or Oxyaquic. Their classification will depend on conditions at the time of sampling and knowledge of the frequency and duration of any drying on exposure. With some submerged soils, evidence of prior surface soil aeration such as the development of mottles, soil structure or very low pH suggests that the soils are not Subaqueous, i.e. subject to permanent saturation. If the period of exposure is insufficient to allow substantial soil aeration and there is no evidence of oxidation and drying, then the soils are considered to be Subaqueous.

In the Salic Suborder the salinisation may or may not be human-induced. Saline water tables may arise as a result of a sequence of wetter-than-average years, or they may result from activities such as a tree clearing and/or unwise irrigation practices. With time it is likely that some of the human-induced saline soils will tend to those of the Hypersalic Suborder, as evidenced in some of the saline valleys of the Western Australian wheat belt. It also follows that a wide range of soils is likely to occur in the Salic Suborder.

In the Redoxic and Oxyaquic Suborders water tables are normally non-saline. However exceptions may occur where these soils are underlain by sulfuric and/or sulfidic materials, as described by Walker (1972). It should be noted that the use of mottling as a diagnostic criterion in the former Suborder does not necessarily imply that oxidising and reducing conditions are currently occurring in the soil in most years.

**Great Groups**

Because of lack of data in the first seven Suborders, further studies may lead to additional Great Groups.

**Subtidal, Intertidal and Subaqueous Hydrosols**

Conventional horizon nomenclature is inapplicable to these soils, hence the use of arbitrary
HYDROSOLS depth limits.

- Soils in which sulfuric material (at least 15 cm thick) occurs within the upper 1.5 m of the profile. **Sulfuric [EV]**

Note: The sulfuric Great Group can be replaced by the following Great Group where appropriate evidence is available:

- Soils in which both monosulfidic material and sulfuric material (at least 15 cm thick) occur within the upper 1.5 m of the profile. **Monosulfidic-Sulfuric [IW]**

- Soils in which sulfidic materials occur within the upper 1.5 m of the profile. **Sulfidic [EU]**

Note: The sulfidic Great Group can be replaced by the following Great Groups where appropriate evidence is available:

- Soils in which both monosulfidic material and hypersulfidic material occur within the upper 1.5 m of the profile. **Monohypersulfidic [IX]**

- Other soils that are dominated by organic materials to a depth of 0.5 m and which have hypersulfidic material within the upper 1.5 m of the profile. **Histic-Hypersulfidic [IY]**

- Other soils in which hypersulfidic material occurs within the upper 1.5 m of the profile. **Hypersulfidic [IZ]**

- Soils in which both monosulfidic material and hyposulfidic material occur within the upper 1.5 m of the profile. **Monohyposulfidic [JA]**

- Other soils that are dominated by organic materials to a depth of 0.5 m and have hyposulfidic material within the upper 1.5 m of the profile. **Histic-Hyposulfidic [IY]**

- Other soils with hyposulfidic material within the upper 1.5 m of the profile. **Hyposulfidic [JC]**

- Other soils that are dominated by organic materials to a depth of 0.5 m. **Histic [CF]**

- The soil materials to a depth of 0.5 m are dominated by other organic-rich (non-vegetative) materials such as faunal debris. **Faunic [FW]**

- The soil materials to a depth of 0.5 m are dominantly calcareous. **Epicalcareous [FY]**

- The soil materials to a depth of 0.5 m are dominantly clay-sized.
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Argillaceous [AQ]
- The soil materials to a depth of 0.5 m are dominantly silt-sized.

Lutaceous [FX]
- The soil materials to a depth of 0.5 m are dominantly sand-sized.

Arenaceous [BV]

Supratidal Hydrosols
- Soils in which sulfuric material (at least 15 cm thick) occurs within the upper 1.5 m of the profile.

Sulfuric [EV]
- Note: The sulfuric Great Group can be replaced by the following Great Group where appropriate evidence is available:
- Soils in which both monosulfidic material and sulfuric material (at least 15 cm thick) occur within the upper 1.5 m of the profile.

Monosulfidic-Sulfuric [IW]
- Soils in which sulfidic materials occur within the upper 1.5 m of the profile.

Sulfidic [EU]
- Note: The sulfidic Great Group can be replaced by the following Great Groups where appropriate evidence is available:
- Soils in which both monosulfidic material and hypersulfidic material occur within the upper 1.5 m of the profile.

Monohypersulfidic [IX]
- Other soils in which hypersulfidic material occurs within the upper 1.5 m of the profile.

Hypersulfidic [IZ]
- Soils in which both monosulfidic material and hyposulfidic material occur within the upper 1.5 m of the profile.

Monohyposulfidic [JA]
- Other soils with hyposulfidic material within the upper 1.5 m of the profile.

Hyposulfidic [JC]
- Soils with a gypsic horizon within the upper 0.5 m of the profile.

Gypsic [BZ]
- Soils in which the major part of the upper 0.5 m of the profile is calcareous.

Epicalcareous [FY]
- Soils in which the major part of the upper 0.5 m of the profile is mottled.

Mottled [DQ]
- Soils in which the major part of the upper 0.5 m of the profile is whole coloured.
Haplic [CD]

**Hypersalic Hydrosols**

- Soils in which sulfuric material (at least 15 cm thick) occurs within the upper 1.5 m of the profile.

**Sulfuric [EV]**

Note: The sulfuric Great Group can be replaced by the following Great Group where appropriate evidence is available:

- Soils in which both monosulfidic material and sulfuric material (at least 15 cm thick) occur within the upper 1.5 m of the profile.

**Monosulfidic-Sulfuric [IW]**

- Soils in which sulfidic materials occur within the upper 1.5 m of the profile.

**Sulfidic [EU]**

Note: The sulfidic Great Group can be replaced by the following Great Groups where appropriate evidence is available:

- Soils in which both monosulfidic material and hypersulfidic material occur within the upper 1.5 m of the profile.

**Monohypersulfidic [IX]**

- Other soils in which hypersulfidic material occurs within the upper 1.5 m of the profile.

**Hypersulfidic [IZ]**

- Soils in which both monosulfidic material and hyposulfidic material occur within the upper 1.5 m of the profile.

**Monohyposulfidic [JA]**

- Other soils with hyposulfidic material within the upper 1.5 m of the profile.

**Hyposulfidic [JC]**

- Soils with a gypsic horizon within the upper 0.5 m of the profile.

**Gypsic [BZ]**

- Soils in which the major part of the upper 0.5 m of the profile consists of materials dominated (>50%) by halite crystals.

**Halic [CC]**

- Soils in which the major part of the upper 0.5 m of the profile is calcareous.

**Epicalcareous [FY]**

- Soils in which the major part of the upper 0.5 m of the profile is mottled.

**Mottled [DQ]**

- Soils in which the major part of the upper 0.5 m of the profile is whole coloured.

**Haplic [CD]**

**Extratidal and Salic Hydrosols**
The provision of Great Groups for these Suborders is incomplete because of lack of data. High salt contents usually tend to obliterate the original morphology, but where this can still be identified, Great Groups may be established on this basis.

- Soils in which sulfuric material (at least 15 cm thick) occurs within the upper 1.5 m of the profile.

**Sulfuric [EV]**

Note: The sulfuric Great Group can be replaced by the following Great Group where appropriate evidence is available:

- Soils in which both monosulfidic material and sulfuric material (at least 15 cm thick) occur within the upper 1.5 m of the profile.

**Monosulfidic-Sulfuric [IW]**

- Soils in which sulfidic materials occur within the upper 1.5 m of the profile.

**Sulfidic [EU]**

Note: The sulfidic Great Group can be replaced by the following Great Groups where appropriate evidence is available:

- Soils in which both monosulfidic material and hypersulfidic material occur within the upper 1.5 m of the profile.

**Monohypersulfidic [IX]**

- Other soils in which hypersulfidic material occurs within the upper 1.5 m of the profile.

**Hypersulfidic [IZ]**

- Soils in which both monosulfidic material and hyposulfidic material occur within the upper 1.5 m of the profile.

**Monohyposulfidic [JA]**

- Other soils with hyposulfidic material within the upper 1.5 m of the profile.

**Hyposulfidic [JC]**

- Soils with a petroferric horizon within the soil profile.

**Petroferric [EA]**

- Soils that are calcareous throughout the soil profile, or at least below the A1 horizon or to a depth of 0.2 m if the A1 horizon is only weakly developed, and do not have a clear or abrupt textural B horizon.

**Calcarosolic [CB]**

- Soils with a clear or abrupt textural B horizon and the major part of the upper 0.2 m of the B2 horizon is strongly acid.

**Kurosolic [CX]**

- Soils with a clear or abrupt textural B horizon that is sodic and not strongly acid in the major part of the upper 0.2 m of the B2 horizon.

**Sodosolic [EQ]**

- Other soils with a <clear or abrupt textural B horizon and the pHw in the major part
of the upper 0.2 m of the B2 horizon is not strongly acid.

**Chromosolic [BG]**

- Soils with structured B2 horizons and which apart from wetness fulfil the requirements for Dermosols.

**Dermosolic [FQ]**

- Other soils with B2 horizons and which apart from wetness fulfil the requirements for Kandosols.

**Kandosolic [FR]**

- Soils which apart from wetness fulfil the requirements for Arenosols.

**Arenosolic [JM]**

- Soils which apart from wetness fulfil the requirements for Tenosols.

**Tenosolic [GT]**

- Soils which apart from wetness fulfil the requirements for Rudosols.

**Rudosolic [GR]**

**Redoxic and Oxyaquic Hydrosols**

The following Great Groups will not all be relevant for each of these two Suborders. For example, the Rudosolic Great Group will not be required for the Redoxic Suborder.

- Soils in which sulfuric material (at least 15 cm thick) occurs within the upper 1.5 m of the profile.

**Sulfuric [EV]**

Note: The sulfuric Great Group can be replaced by the following Great Group where appropriate evidence is available:

- Soils in which both monosulfidic material and sulfuric material (at least 15 cm thick) occur within the upper 1.5 m of the profile.

**Monosulfidic-Sulfuric [IW]**

- Soils in which sulfidic materials occur within the upper 1.5 m of the profile.

**Sulfidic [EU]**

Note: The sulfidic Great Group can be replaced by the following Great Groups where appropriate evidence is available:

- Soils in which both monosulfidic material and hypersulfidic material occur within the upper 1.5 m of the profile.

**Monohypersulfidic [IX]**

- Other soils in which hypersulfidic material occurs within the upper 1.5 m of the profile.

**Hypersulfidic [IZ]**

- Soils in which both monosulfidic material and hyposulfidic material occur within the upper 1.5 m of the profile.

**Monohyposulfidic [JA]**
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- Other soils with hyposulfidic material within the upper 1.5 m of the profile. **Hyposulfidic [JC]**
- Soils with a petroferric horizon within the soil profile. **Petroferric [EA]**
- Soils which are calcareous throughout the soil profile, or at least below the A1 or Ap horizon or to a depth of 0.2 m if the A1 horizon is only weakly developed, and do not have a clear or abrupt textural B horizon. **Calcarosolic [CB]**
- Soils with a clear or abrupt textural B horizon and the major part of the upper 0.2 m of the B2 horizon is strongly acid. **Kurosolic [CX]**
- Soils with a clear or abrupt textural B horizon which is sodic and not strongly acid in the major part of the upper 0.2 m of the B2 horizon. **Sodosolic [EQ]**
- Other soils with a clear or abrupt textural B horizon and the pH in the major part of the upper 0.2 m of the B2 horizon is not strongly acid. **Chromosolic [BG]**
- Soils with structured B2 horizons and which apart from wetness fulfil the requirements for Dermosols. **Dermosolic [FQ]**
- Other soils with B2 horizons and which apart from wetness fulfil the requirements for Kandosols. **Kandosolic [FR]**
- Soils that apart from wetness fulfil the requirements for Arenosols. **Arenosolic [JM]**
- Soils that apart from wetness fulfil the requirements for Tenosols. **Tenosolic [GT]**
- Soils that apart from wetness fulfil the requirements for Rudosols. **Rudosolic [GR]**

Subgroups

No Subgroups for the Subtidal, Subaqueous, Supratidal, Extratidal and Hypersalic Hydrosols are formally proposed at present because of insufficient data.

Subgroups of Intertidal Hydrosols

The following three Subgroups will only be applicable to the Histic-Hypersulfidic and Histic-Hyposulfidic Great Groups.

- Soils in which the organic materials are dominated (about 75% by volume) by fibric peat. **Fibric [BW]**
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Soils in which the organic materials are dominated by hemic peat.

Hemic [CE]

Soils in which the organic materials are dominated by sapric peat.

Sapric [EH]

Subgroups of Salic Hydrosols

The following three Subgroups have been identified for several Great Groups in the Salic Suborder. Other possibly relevant Subgroups may be found listed below in the Subgroups for the Redoxic and Oxyaquic Suborders.

- Soils with sulfidic materials in the A or near surface horizons and which directly overlie a calcrete pan.

Episulfidic-Petrocalcic [HM]

- Other soils with sulfidic materials in the A or near surface horizons.

Episulfidic [HL]

- Other soils that directly overlie a calcrete pan.

Petrocalcic [DZ]

Subgroups of Redoxic and Oxyaquic Hydrosols

It is thought that the following Subgroups will cater for most situations, although obviously some will not be relevant for particular Great Groups. As examples, the Acidic Subgroups will not be required for the Kurosolic Great Groups, nor the Sodic and Natric classes for the Sodosolic Great Group. Although presently not listed, a Petrocalcic Subgroup may be required for the Calcarosolic Great Group. If so, a definition is available above. Some additional Subgroups will be required for the Sulfuric and Sulfidic Great Groups as knowledge of these soils increases e.g. a possible subdivision could be based on the nature of the soil profile above the sulfuric or sulfidic materials that commonly occur as a D horizon.

"In the case of the Rudosolic and Tenosolic Great Groups, the most appropriate Subgroups will be those used for the relevant Suborders and Great Groups of Rudosols and Tenosols.

- Soils that have been partly modified by high temperature burning of organic materials. Such soils have surface layers that comprise >20% of fusic material.

Fusic [IT]

- Soils with a peaty horizon and a thin ironpan that occurs within or directly underlying the B horizon.

Peaty-Placic [GD]

- Other soils with a peaty horizon

Peaty [DW]

- Soils with a humose horizon and a B2 horizon in which the major part has an exchangeable Ca/Mg ratio of less than 0.1.

Humose-Magnesic [CL]

- Soils with a humose horizon and the major part of the B2 horizon is strongly acid.

Humose-Acidic [GY]
calcareous.

**Humose-Calcareous [GU]**
- Soils with a humose horizon and a conspicuously bleached A2 horizon.

**Humose-Bleached [EY]**
- Other soils with a humose horizon.

**Humose [CK]**
- Soils with a melacic horizon and a B2 horizon in which the major part has an exchangeable Ca/Mg ratio of less than 0.1.

**Melacic-Magnesic [DH]**
- Soils with a melacic horizon and a conspicuously bleached A2 horizon.

**Melacic-Bleached [EZ]**
- Other soils with a melacic horizon.

**Melacic [DG]**
- Soils with a melanic horizon and a conspicuously bleached A2 horizon.

**Melanic-Bleached [DL]**
- Soils with a melanic horizon and a B horizon in which at least 0.3m has vertic properties.

**Melanic-Vertic [DN]**
- Soils with a melanic horizon and the major part of the B2 horizon is strongly acid.

**Melanic-Acidic [FV]**
- Other soils with a melanic horizon.

**Melanic [DK]**
- Soils with a conspicuously bleached A2 horizon and a B horizon in which at least 0.3m has vertic properties.

**Bleached-Vertic [BB]**
- Other soils with a B horizon in which at least 0.3 m has vertic properties.

**Vertic [EX]**
- Soils with a ferric horizon within the soil profile and a B2 horizon in which the major part is strongly acid.

**Ferric-Acidic [GW]**
- Soils with a ferric horizon within the soil profile and a B horizon in which at least the lower part is sodic.

**Ferric-Sodic [HC]**
- Soils with a conspicuously bleached A2 horizon and a ferric horizon within the soil profile.

**Bleached-Ferric [AV]**
• Other soils with a ferric horizon within the soil profile.

  **Ferric [BU]**

• Soils with a manganic horizon within the soil profile and a B2 horizon in which the major part is strongly acid.

  **Manganic-Acidic [GX]**

• Soils with a conspicuously bleached A2 horizon and a manganic horizon within the soil profile.

  **Bleached-Manganic [AY]**

• Other soils with a manganic horizon within the soil profile.

  **Manganic [DC]**

• Soils with a hard siliceous pan in the lower A and/or upper B horizon.

  **Silpanic [EM]**

• Soils in which the major part of the B2 horizon is strongly acid and at least the lower part is sodic.

  **Acidic-Sodic [HO]**

• Soils with a conspicuously bleached A2 horizon and a B2 horizon in which the major part is strongly acid.

  **Bleached-Acidic [AU]**

• Other soils with a B2 horizon in which the major part is strongly acid.

  **Acidic [AI]**

• Soils that have an exchangeable Ca/Mg ratio of less than 0.1 in the major part of the B2 horizon, and the major part of the upper 0.2 m of the B2 horizon is sodic.

  **Magnesic-Natric [GP]**

• Soils in which the major part of the upper 0.2 m of the B2 horizon is sodic.

  **Natric [FD]**

• Soils with a conspicuously bleached A2 horizon and a B horizon in which at least the lower part is sodic.

  **Bleached-Sodic [BA]**

• Other soils with a B horizon in which at least the lower part is sodic

  **Sodic [EO]**

• Soils with a reticulate horizon below the B2 horizon.

  **Reticulate [EF]**

• Soils with a conspicuously bleached A2 horizon and a B2 horizon in which the major part has an exchangeable Ca/Mg ratio of less than 0.1.

  **Bleached-Magnesic [AX]**

• Soils with an exchangeable Ca/Mg ratio of less than 0.1 in the major part of the B2 horizon.
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Magnesic [DB]

- Other soils with a conspicuously bleached A2 horizon.

Bleached [AT]

- Soils in which the major part of the B2 horizon is dystrophic.

Dystrophic [AF]

- Soils in which the major part of the B2 horizon is mesotrophic.

Mesotrophic [AG]

- Soils in which the major part of the B2 horizon is eutrophic but the B and BC horizons are not calcareous.

Eutrophic [AH]

- Soils in which at least some part of the B or the BC horizon is calcareous.

Calcareous [BC]

Family Criteria

The classes below are primarily for use in the Redoxic and Oxyaquic Suborders, and possibly the Extratidal and Salic Suborders. The criteria may be partly applicable to the Supratidal and Hypersalic Suborders e.g. using the terms surface soil and maximum subsoil texture. The different A horizon thickness criteria for Great Groups with a Clear or abrupt textural B horizon allows alignment with their adjacent but drier equivalent Soil Orders.

Water repellence of surface soil

Non water repellent [NR] : Water absorbed in 10 seconds or less
Water repellent [WR] : Water takes more than 10 seconds and 2 Molar ethanol takes 10 seconds or less to be absorbed into soil.
Strongly water repellent [SR] : 2 Molar ethanol takes greater than 10 seconds or less to be absorbed into soil

A horizon thickness, or thickness of organic horizon (O2, P1 or P2) if present (for Chromosolic, Kurosolic and Sodosolic Great Groups)

Thin [A] : <0.1 m
Moderately thick [B] : 0.1–<0.3 m
Thick [C] : 0.3–0.6 m
Very thick [D] : >0.6 m

A1 horizon thickness, or thickness of organic horizon (O2, P1 or P2) if present (for all other Great Groups)

Thin [A] : <0.1 m
Moderately thick [B] : 0.1–<0.3 m
Thick [C] : 0.3–0.6 m
Very thick [D] : >0.6 m

Gravel of the surface and A1 horizon

Non-gravelly [E] : <2%
Slightly gravelly [F] : 2–<10%
Gravelly [G] : 10–<20%
HYDROSOLS

Moderately gravelly  \[H\] : 20–50%
Very gravelly \[I\] : >50%

A1 horizon texture, or texture of organic horizon (O2, P1 or P2) if present
Peaty \[J\] : Dominated by organic materials
Sandy \[K\] : S-LS-CS (up to 10% clay)
Loamy \[L\] : SL-L (10-20% clay)
Clay loamy \[M\] : SCL-CL (20-35% clay)
Silty \[N\] : ZL-ZCL (25-35% clay and silt 25% or more)
Clayey \[O\] : LC-MC-HC (>35% clay)

B horizon maximum texture\(^1\)
Sandy \[K\] : S-LS-CS (up to 10% clay)
Loamy \[L\] : SL-L (10-20% clay)
Clay loamy \[M\] : SCL-CL (20-35% clay)
Silty \[N\] : ZL-ZCL (25-35% clay and silt 25% or more)
Clayey \[O\] : LC-MC-HC (more than 35% clay)

Soil depth
Very shallow \[T\] : <0.25 m
Shallow \[U\] : 0.25–<0.5 m
Moderately deep \[V\] : 0.5–<1.0 m
Deep \[W\] : 1.0–<1.5 m
Very deep \[X\] : 1.5–5 m
Giant \[Y\] : >5 m
Kandosols [KA]

[ Pronounced Can-doh-sols ]

Concept
This Order accommodates those soils that lack strong texture contrast, have massive or only weakly structured B horizons, and are not calcareous throughout. The soils of this Order range throughout the continent, often occurring locally as very large areas.

Definition
Soils other than Hydrosols that have all of the following:
1. B2 horizons in which the major part has a grade of pedality that is massive or weak.
2. A maximum clay content in some part of the B2 horizon that exceeds 15% (i.e. heavy sandy loam [SL+] or heavier).
3. Do not have a tenic B horizon.
4. Do not have a clear or abrupt textural B horizon.
5. Are not calcareous throughout the solum, or below the A1 or Ap horizon or to a depth of 0.2 m if the A1 horizon is only weakly developed.

Comment
Because of the lack of clearly defined horizons in some of these soils (particularly the red forms) with thick sola, there can be argument as to how to identify the limits of the B2 horizon.

As noted under Tenosols (see Comment following Definition), there may also be difficulty in deciding whether B horizon development is strong enough for the soil to be classed as a Kandosol, or is only weak and better classed as a tenic B horizon.

There may be difficulty differentiating between Kandosols and Arenosols, where texture and horizon development is weak and sandy textures dominate. Some Kandosols have very thick A and/or B1 horizons with sandy textures that overlie at >1m deep, B2t horizons that exceed 15% clay.

Suborders
The dominant colour class in the major part of the upper 0.5 m of the B2 horizon (or the major part of the entire B2 horizon if it is less than 0.5 m thick) is:

- Red.
  Red [AA]

- Brown.
  Brown [AB]

- Yellow.
  Yellow [AC]

- Grey.
Grey [AD]

Black [AE]

**Great Groups**

It is thought that most of the following Great Group categories will be appropriate for the various Suborders. At present the Duric and Mellic Great Groups are only known to occur in Red or Brown Kandosols, particularly the former. The Duric soils are confined to the arid zone.

- Soils with a red-brown hardpan either within or directly underlying the B horizon.
  
  **Duric [BJ]**

- Soils with a B horizon either containing or directly underlain by ferricrete, a petroferric horizon, or a petroreticulate horizon.
  
  **Petroferric [EA]**

- Soils with a B horizon that is not calcareous and which directly overlies a calcrite pan.
  
  **Petrocalcic [DZ]**

- Soils with a thin ironpan that occurs within or directly underlying the B horizon.
  
  **Placic [EC]**

- Soils with massive to weakly structured (about 10 mm subangular blocky parting to finer granules) B horizons that are very porous with a weak consistence strength when moist. Bulk density appears to be relatively low. (See Comment below).
  
  **Mellic [DO]**

- Soils with an exchangeable Ca/Mg ratio of less than 0.1 in the major part of the B2 horizon.
  
  **Magnesic [DB]**

- Soils in which the major part of the B2 horizon is dystrophic.
  
  **Dystrophic [AF]**

- Soils in which the major part of the B2 horizon is mesotrophic.
  
  **Mesotrophic [AG]**

- Soils in which the major part of the B2 horizon is eutrophic but the B and BC horizons are not calcareous.
  
  **Eutrophic [AH]**

- Soils in which the carbonate is evident only as a slight to moderate effervescence (1M HCl), and/or contain less than 2% soft finely divided carbonate, and have less than 20% hard carbonate nodules or concretions.
  
  **Hypocalcic [CV]**

- Soils with a calcareous horizon containing more than 50% of hard calcrite fragments and/or carbonate nodules or concretions and/or carbonate-coated gravel.
Lithocalcic [DA]

- Soils with a calcareous horizon containing 20–50% of hard calcrete fragments and/or carbonate nodules or concretions and/or carbonate-coated gravel.

Supracalcic [FB]

- Soils with a calcareous horizon containing more than 20% of mainly soft, finely divided carbonate, and 0–20% of hard calcrete fragments and/or carbonate nodules or concretions, and/or carbonate-coated gravel.

Hyperccalcic [CQ]

- Other soils with a calcareous horizon. (See carbonate classes).

Calcic [BD]

Comment

The calcareous classes above approximately correspond to those of Wetherby and Oades (1975) as follows: Hypocalcic - Class IV, Lithocalcic - Class III B and IIIC, Supracalcic - Class III B, Hypercalcic - Class III A, Calcic - Class I and IIIA. In the Lithocalcic and Supracalcic classes the coarse fragments may be >0.2 m in size and soft carbonate may or may not be present.

The Mellic soils are very common but little-known acid soils in the high rainfall–high altitude forested areas of south eastern mainland Australia and Tasmania. Structure is often difficult to determine because of weak consistence strength and the usual presence of more than 20% of rock fragments throughout the profile. Any peds present do not possess smooth faces.

Subgroups

It is thought that the following Subgroups will cater for most situations, although obviously some will not be relevant for particular Great Groups of particular Suborders. As an example, the various acidic Subgroups will not be required for the calcareous Great Groups.

- Soils with a humose horizon and the major part of the B2 horizon is mottled.
  Humose-Mottled [CM]

- Soils with a humose horizon and the major part of the B2 horizon is strongly acid.
  Humose-Acidic [GY]

- Other soils with a humose horizon.
  Humose [CK]

- Soils with a melacic horizon and the major part of the B2 horizon is mottled.
  Melacic-Mottled [DI]

- Other soils with a melacic horizon.
  Melacic [DG]

- Soils with a melanic horizon and the major part of the B2 horizon is mottled.
  Melanic-Mottled [DM]

- Soils with a melanic horizon and the major part of the B2 horizon is strongly acid.
Melanic-Acidic [FV]
- Other soils with a melanic horizon.

Melanic [DK]
- Soils with an argic horizon within the B horizon.

Argic [AP]
- Soils with a bauxitic horizon within the B horizon.

Bauxitic [AS]
- Soils with a ferric horizon within the solum and a B2 horizon in which the major part is strongly acid.

Ferric-Acidic [GW]
- Soils with a ferric horizon within the solum and a B horizon in which at least the lower part is sodic.

Ferric-Sodic [HC]
- Soils with a conspicuously bleached A2 horizon and a ferric horizon within the solum.

Bleached-Ferric [AV]
- Other soils with a ferric horizon within the solum.

Ferric [BU]
- Soils with a manganic horizon within the solum and a B2 horizon in which the major part is strongly acid.

Manganic-Acidic [GX]
- Soils with a conspicuously bleached A2 horizon and a manganic horizon within the solum.

Bleached-Manganic [AY]
- Other soils with a manganic horizon within the solum.

Manganic [DC]
- Soils in which the major part of the B2 horizon is strongly acid and at least the lower part of the B horizon is sodic.

Acidic-Sodic [HO]
- Soils with a conspicuously bleached A2 horizon and a B2 horizon in which the major part is strongly acid.

Bleached-Acidic [AU]
- Soils in which the major part of the B2 horizon is strongly acid and mottled.

Acidic-Mottled [AJ]
- Other soils with a B2 horizon in which the major part is strongly acid.

Acidic [AI]
• Soils with a conspicuously bleached A2 horizon and a B horizon in which at least the lower part is sodic.

   **Bleached-Sodic [BA]**

• Soils in which the major part of the B2 horizon is mottled and at least the lower part of the B horizon is sodic.

   **Mottled-Sodic [HB]**

• Other soils with a B horizon in which at least the lower part is sodic.

   **Sodic [EO]**

• Soils with a conspicuously bleached A2 horizon and the major part of the B2 horizon is mottled.

   **Bleached-Mottled [AZ]**

• Other soils with a conspicuously bleached A2 horizon.

   **Bleached [AT]**

• Soils with a reticulate horizon below the B2 horizon.

   **Reticulate [EF]**

• Other soils in which the major part of the B2 horizon is mottled.

   **Mottled [DQ]**

• Other soils in which the major part of the B2 horizon is whole coloured.

   **Haplic [CD]**

**Comment**

In some of the Dystrophic Kandosols there may be a future need to modify the definition of sodic Subgroups. (See ESP). As in Chromosols, Dermosols and Ferrosols, Haplic is the most common Subgroup. While this could indicate a need for further subdivision, it is difficult to find criteria that could be used.

**Family Criteria**

**Water repellence of surface soil**

- Non water repellent  **[NR]** : Water absorbed in 10 seconds or less
- Water repellent  **[WR]** : Water takes more than 10 seconds and 2 Molar ethanol takes 10 seconds or less to be absorbed into soil.
- Strongly water repellent  **[SR]** : 2 Molar ethanol takes greater than 10 seconds or less to be absorbed into soil

**A1 horizon thickness, or thickness of organic horizon (O2, P1 or P2) if present**

- Thin  **[A]** : <0.1 m
- Moderately thick  **[B]** : 0.1–<0.3 m
- Thick  **[C]** : 0.3–0.6 m
- Very thick  **[D]** : >0.6 m

**Gravel of the surface and A1 horizon**

- Non-gravelly  **[E]** : <2%
### KANDOSOLS

<table>
<thead>
<tr>
<th>Texture</th>
<th>Symbol</th>
<th>Percentage</th>
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</thead>
<tbody>
<tr>
<td>Slightly gravelly</td>
<td>[F]</td>
<td>2–10%</td>
</tr>
<tr>
<td>Gravelly</td>
<td>[G]</td>
<td>10–20%</td>
</tr>
<tr>
<td>Moderately gravelly</td>
<td>[H]</td>
<td>20–50%</td>
</tr>
<tr>
<td>Very gravelly</td>
<td>[I]</td>
<td>&gt;50%</td>
</tr>
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</table>

**A1 horizon texture, or texture of organic horizon (O2, P1 or P2) if present**

<table>
<thead>
<tr>
<th>Texture</th>
<th>Symbol</th>
<th>Description</th>
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<tbody>
<tr>
<td>Peaty</td>
<td>[J]</td>
<td>Dominated by organic materials</td>
</tr>
<tr>
<td>Sandy</td>
<td>[K]</td>
<td>S-LS-CS (up to 10% clay)</td>
</tr>
<tr>
<td>Loamy</td>
<td>[L]</td>
<td>SL-L (10-20% clay)</td>
</tr>
<tr>
<td>Clay loamy</td>
<td>[M]</td>
<td>SCL-CL (20-35% clay)</td>
</tr>
<tr>
<td>Silty</td>
<td>[N]</td>
<td>ZL-ZCL (25-35% clay and silt 25% or more)</td>
</tr>
<tr>
<td>Clayey</td>
<td>[O]</td>
<td>LC-MC-HC (&gt;35% clay)</td>
</tr>
</tbody>
</table>

**B horizon maximum texture**

<table>
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<tr>
<th>Texture</th>
<th>Symbol</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
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<tr>
<td>Clayey</td>
<td>[O]</td>
<td>LC-MC-HC (more than 35% clay)</td>
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**Soil depth**

<table>
<thead>
<tr>
<th>Depth</th>
<th>Symbol</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very shallow</td>
<td>[T]</td>
<td>&lt;0.25 m</td>
</tr>
<tr>
<td>Shallow</td>
<td>[U]</td>
<td>0.25–&lt;0.5 m</td>
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<tr>
<td>Moderately deep</td>
<td>[V]</td>
<td>0.5–&lt;1.0 m</td>
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<tr>
<td>Deep</td>
<td>[W]</td>
<td>1.0–&lt;1.5 m</td>
</tr>
<tr>
<td>Very deep</td>
<td>[X]</td>
<td>1.5–5 m</td>
</tr>
<tr>
<td>Giant</td>
<td>[Y]</td>
<td>&gt;5 m</td>
</tr>
</tbody>
</table>

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1 This refers to the most clayey field texture category.
Kurosols [KU]

[Pronounced Cure-oh-sols]

Concept
Soils with strong texture contrast between A horizons and strongly acid B horizons. Many of these soils have some unusual subsoil chemical features (high magnesium, sodium and aluminium).

Definition
Soils other than Hydrosols with a clear or abrupt textural B horizon and in which the major part of the upper 0.2 m of the B2t horizon (or the major part of the entire B2t horizon if it is less than 0.2 m thick) is strongly acid.

Comment
The relevance of sodicity in strongly acid soils is open to question as in theory the presence of aluminium in such soils should counterbalance the usual deleterious effect of sodium (via dispersion) on soil physical properties. Unpublished data from many localities in Australia imply that for B horizons the critical limits of pHw 5.5 and ESP of 6 to distinguish dispersive and non-dispersive soils seems to generally work in practice, although as might be expected, some soils do not behave as predicted. For this reason, sodicity is also used in Kurosols, but at a lower hierarchical level, to cater for those soils that have an ESP >6 and may disperse in spite of having a pHw less than 5.5. The role of the high exchangeable magnesium in many Kurosols is largely unknown.

Suborders
The dominant colour class in the major part of the upper 0.2 m of the B2t horizon (or the major part of the entire B2t horizon if it is less than 0.2 m thick) is:

- Red.
  - Red [AA]

- Brown.
  - Brown [AB]

- Yellow.
  - Yellow [AC]

- Grey.
  - Grey [AD]

- Black.
  - Black [AE]

Great Groups
These will vary somewhat among the various colour class Suborders, but it is likely that the subdivisions given below will apply to most.
Soils with a petroferric horizon within the solum.

**Petroferric [EA]**

Soils with an exchangeable Ca/Mg ratio of less than 0.1 in the major part of the B2t horizon, and the major part of the upper 0.2 m of the B2t horizon is sodic.

**Magnesic-Natric [GP]**

Other soils with an exchangeable Ca/Mg ratio of less than 0.1 in the major part of the B2t horizon.

**Magnesic [DB]**

Other soils in which the major part of the upper 0.2 m of the B2t horizon is sodic.

**Natric [FD]**

Soils in which the major part of the B2t horizon is dystrophic.

**Dystrophic [AF]**

Soils in which the major part of the B2t horizon is mesotrophic.

**Mesotrophic [AG]**

Soils in which the major part of the B2t horizon is eutrophic.

**Eutrophic [AH]**

Comment

A feature of the soils classified is the common occurrence of high subsoil exchangeable magnesium with or without sodium. In spite of an upper B2t horizon that is strongly acid, Mesotrophic Great Groups are more common than the Dystrophic forms. This is often related to relatively high magnesium values.

Subgroups

The Subgroups listed will not all be relevant for every Great Group. e.g. Sodic classes will not be required for the Natric Great Groups.

- Soils with a humose horizon and a conspicuously bleached A2 horizon.

  **Humose-Bleached [EY]**

- Other soils with a humose horizon.

  **Humose [CK]**

- Soils with a melacic horizon and a conspicuously bleached A2 horizon.

  **Melacic-Bleached [EZ]**

- Other soils with a melacic horizon.

  **Melacic [DG]**

- Soils with a melanic horizon and a B horizon in which at least 0.3 m has vertic properties.

  **Melanic-Vertic [DN]**

- Other soils with a melanic horizon.
KUROSOLS

Melanic [DK]

- Soils with a conspicuously bleached A2 horizon and a B horizon in which at least 0.3 m has vertic properties.

Bleached-Vertic [BB]

- Other soils with a B horizon in which at least 0.3 m has vertic properties.

Vertic [EX]

- Soils with a conspicuously bleached A2 horizon and a ferric horizon within the solum.

Bleached-Ferric [AV]

- Other soils with a ferric horizon within the solum.

Ferric [BU]

- Soils with a conspicuously bleached A2 horizon and a manganic horizon within the solum.

Bleached-Manganic [AY]

- Other soils with a manganic horizon within the solum.

Manganic [DC]

- Soils with a conspicuously bleached A2 horizon and a B horizon in which at least the lower part is sodic.

Bleached-Sodic [BA]

- Soils in which the major part of the B2t horizon is mottled and at least the lower part of the B horizon is sodic.

Mottled-Sodic [HB]

- Other soils with a B horizon in which at least the lower part is sodic.

Sodic [EO]

- Soils with a conspicuously bleached A2 horizon and the major part of the B2t horizon is mottled.

Bleached-Mottled [AZ]

- Other soils with a conspicuously bleached A2 horizon.

Bleached [AT]

- Soils with a reticulate horizon below the B2t horizon.

Reticulate [EF]

- Other soils in which the major part of the B2t horizon is mottled.

Mottled [DQ]

- Other soils in which the major part of the B2t horizon is whole coloured.
Comment

A significant proportion of the soils classified to date have mottled B2t horizons, which suggests a trend to poorer internal drainage in the Kurosols compared to Chromosols.

Family Criteria

Water repellence of surface soil

Non water repellent [NR] : Water absorbed in 10 seconds or less
Water repellent [WR] : Water takes more than 10 seconds and 2 Molar ethanol takes 10 seconds or less to be absorbed into soil.
Strongly water repellent [SR] : 2 Molar ethanol takes greater than 10 seconds or less to be absorbed into soil.

A horizon thickness, or thickness of organic horizon (O2, P1 or P2) if present

Thin [A] : <0.1 m
Moderately thick [B] : 0.1–<0.3 m
Thick [C] : 0.3–0.6 m
Very thick [D] : >0.6 m

Gravel of the surface and A1 horizon

Non-gravelly [E] : <2%
Slightly gravelly [F] : 2–<10%
Gravelly [G] : 10–<20%
Moderately gravelly [H] : 20–50%
Very gravelly [I] : >50%

A1 horizon texture, or texture of organic horizon (O2, P1 or P2) if present

Peaty [J] : Dominated by organic materials
Sandy [K] : S-LS-CS (up to 10% clay)
Loamy [L] : SL-L (10-20% clay)
Clay loamy [M] : SCL-CL (20-35% clay)
Silty [N] : ZL-ZCL (25-35% clay and silt 25% or more)
Clayey [O] : LC-MC-HC (>35% clay)

B horizon maximum texture

Clay loamy [M] : SCL-CL (20-35% clay)
Silty [N] : ZL-ZCL (25-35% clay and silt 25% or more)
Clayey [O] : LC-MC-HC (more than 35% clay)

Soil depth

Very shallow [T] : <0.25 m
Shallow [U] : 0.25–<0.5 m
Moderately deep [V] : 0.5–<1.0 m
Deep [W] : 1.0–<1.5 m
Very deep [X] : 1.5–5 m
Giant [Y] : >5 m

1 This refers to the most clayey field texture category.
Organosols [OR]

[Proounced Or-gan-oh-sols]

Concept
This class caters for most soils dominated by organic materials. Although they are found from the wet tropics to the alpine regions, areas are mostly small except in south west Tasmania. There have been few previous attempts to subdivide these soils and data are limited in Australia.

Definition
Soils that are not regularly inundated by saline tidal waters and either:
Have more than 0.4 m of organic materials within the upper 0.8 m. The required thickness may either extend down from the surface or be taken cumulatively within the upper 0.8 m. or
Have organic materials extending from the surface to a minimum depth of 0.1 m; these either overlie unconsolidated material no thicker than the organic materials above, or directly overlie rock or other hard layers, partially weathered or decomposed rock or saprolite, or overlie fragmental material such as gravel, cobbles or stones in which the interstices are filled or partially filled with organic material. In some soils there may be layers of humose and/or melacic horizon material underlying the organic materials and overlying the substrate.

Comment
The above definition is similar to definitions of organic soils in Soil Taxonomy (Soil Survey Staff 2014) and in Canada (Canada Soil Survey Committee 1978).

Suborders

- Soils in which the organic materials are dominated (about 75% by volume) by fibric peat.
  
  **Fibric [BW]**

- Soils in which the organic materials are dominated by hemic peat.
  
  **Hemic [CE]**

- Soils in which the organic materials are dominated by sapric peat.
  
  **Sapric [EH]**

Comment
These Suborders are essentially the same as in Soil Taxonomy. The terms fibric, hemic and sapric correspond to fibrous, mesic (semifibrous) and humic as used in Canada and England and Wales. In some north Queensland seasonal swamps, thick peats can have 0.3–0.4 m of sapric over hemic and/or fibric peat. When more data are available it may be necessary to modify the Suborder definitions to cater for soils where the type of peat changes with depth.
Great Groups

It is likely that not all of the Great Groups below will be applicable to each Suborder. It is also likely that other Great Groups will be required as knowledge increases.

- Soils that are more or less freely drained and are never saturated for more than several days unless rain is falling and contain organic materials that occur as in Definition (ii) of Organosols.

  Folic [IF]

- Soils in which sulfuric material (at least 15 cm thick) occurs within the upper 1.5 m of the profile.

  Sulfuric [EV]

Note: The sulfuric Great Group can be replaced by the following Great Group where appropriate evidence is available:

- Soils in which both monosulfidic material and sulfuric material (at least 15 cm thick) occur within the upper 1.5m of the profile.

  Monosulfidic-Sulfuric [IW]

- Soils in which sulfidic materials occur within the upper 1.5 m of the profile.

  Sulfidic [EU]

Note: The sulfidic Great Group can be replaced by the following Great Groups where appropriate evidence is available:

- Soils in which both monosulfidic material and hypersulfidic material occur within the upper 1.5m of the profile.

  Monohypersulfidic [IX]

- Other soils in which hypersulfidic material occurs within the upper 1.5 m of the profile.

  Hypersulfidic [IZ]

- Soils in which both monosulfidic material and hyposulfidic material occur within the upper 1.5 m of the profile.

  Monohyposulfidic [JA]

- Other soils with hyposulfidic material within the upper 1.5 m of the profile.

  Hyposulfidic [JC]

- Soils in which the major part of the organic materials is calcareous.

  Calcareous [BC]

- Soils in which the major part of the organic materials is not calcareous but is not strongly acid.

  Basic [AR]

- Soils in which the major part of the organic materials is strongly acid.

  Acidic [AI]

Subgroups
The following Subgroups may not be relevant to all Great Groups of each Suborder, and future investigations may reveal additional Subgroups.

- Soils in which the organic materials directly overlie hard rock.
  
  **Lithic [CZ]**

- Soils in which the organic materials directly overlie partially weathered or decomposed rock or saprolite.
  
  **Paralithic [DU]**

- Soils with a marl layer either within or immediately below the section containing the organic materials.
  
  **Marly [DD]**

- Soils in which the organic materials directly overlie fragmental material such as gravel, cobbles or stones in which the interstices are filled or partially filled with organic material.
  
  **Rudaceous [HD]**

- Soils in which layers of humose and/or melacic horizon material underlie the organic materials and overlie the substrate.
  
  **Modic [IJ]**

- Soils with a thin ironpan below the organic materials.
  
  **Placic [EC]**

- Soils that have been partly modified by high temperature burning of organic materials. Such soils have surface layers that comprise >20% of fusic material.
  
  **Fusic [IT]**

- Soils in which the organic materials show evidence of burnt peat (often in the form of coloured ash layers) within 0.8m of the surface.
  
  **Ashy [HZ]**

- Soils with a layer (or layers) of unconsolidated mineral material within or below the organic materials but within 0.8 m of the surface.
  
  **Terric [FS]**

- Other soils with a layer (or layers) of unconsolidated mineral material that occurs below 0.8 m of the surface.
  
  **Regolithic [GF]**
Possible Family Criteria

**Nature of uppermost organic materials**
The term granular [P] is applied if there is a surface layer at least 0.2 m thick which has a distinct granular or subangular blocky structure. This condition occurs in peat soils that have been either drained or drained and cultivated, and is also known as earthy or ripened peat. In Australia it is known to occur with sapric peats, but it is uncertain if it occurs with hemic or fibric peats.

**Cumulative thickness of organic materials**

<table>
<thead>
<tr>
<th>Thickness</th>
<th>Code</th>
<th>Thickness Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very thin</td>
<td>[T]</td>
<td>&lt;0.25 m</td>
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<td>[Y]</td>
<td>&gt;5 m</td>
</tr>
</tbody>
</table>
Podosols [PO]

[Pronounced Pod-oh-sols]

Concept
Soils with B horizons dominated by the accumulation of compounds of organic matter, aluminium and/or iron. These soils are recognised world-wide, and Australia is particularly noted for its 'giant' forms.

Definition
Soils that possess either a Bs horizon (visible dominance of iron compounds), a Bhs horizon (organic-aluminium and iron compounds), or a Bh horizon (organic-aluminium compounds). These horizons may occur singly in a profile or in combination (see Podosol diagnostic horizons).

Comment
Extensive revisions of the classification of Spodosols and Podzols have taken place in the USA (with world-wide input) and New Zealand. It is clear that there is considerable diversity of opinion on the desirability, nature and efficacy of chemical criteria to define Spodosols/Podzols. For this reason the present proposal for Australian 'podzols' has deliberately avoided the use of chemical diagnostic criteria. It is realised that problems may arise in distinguishing a Bs horizon from a tenic B horizon; the diagnostic feature of the former is the presence of discontinuous patches or a thin band of darker organic accumulations.

Some Podosols with deep diagnostic B horizons may classify initially as Bleached Arenosols. Only deep examination of the soil profile can confirm the Order of such soils.

Suborders
These are based on soil and site drainage conditions. The intention is to separate soils with no short-term saturation in the B horizon, those with short-term saturation of the B horizon, and those that are saturated for long periods in the B horizon.

••• Soils with free drainage, i.e. rapidly drained. There is no restriction to through drainage in the B horizon or within the substrate. There is no perching of water within the B horizon or saturation due to a high ground water table. The B horizons are weakly coherent and porous. They are often brightly coloured, and lack evidence of seasonal reduction.

Aeric [AL]

••• Soils with short-term saturation in the B horizon. The saturation may be caused by impedance within the B horizon, perching of water by substrate material, or by seasonally high groundwater tables. The duration of saturation may range from several days to several weeks but is insufficient to reduce and remove significant amounts of the accumulated iron. However, there may be a greater accumulation of organic compounds and less iron in the zone of maximum saturation.

Semiaquic [EJ]

••• Soils with long-term saturation in the B horizon and sulfuric material (at least 15 cm thick) is present in the A or B horizons.
**Aquic-Sulfuric [JD]**

- Soils with long-term saturation in the B horizon and hypersulfidic material is present in the A or B horizons.

**Aquic-Hypersulfidic [JE]**

- Soils with long-term saturation in the B horizons. The saturation may be caused as in the semiaquic soils but the duration is of the order of months. The period of saturation is sufficient to reduce most iron compounds and move them out of the B horizon, hence Bh horizons are usually prominent.

**Aquic [AM]**

**Great Groups**

Classes are based on observable B horizon characteristics reflecting the dominance of organic or iron compounds and their distribution in the accumulation zone. The organic accumulations can usually be recognised by their dark colours and the iron compounds by generally bright colours. Aluminium is always present, usually complexed by organic matter and therefore not usually visible, except in some horizons where large amounts of amorphous aluminium and silica (imogolite-allophane complexes) may induce a yellowish brown colouration. Yellowish brown bands in poorly-drained B horizons should not be interpreted as evidence of iron compounds without chemical verification.

**Aeric Podosols**

- Soils with a pipey B horizon.

  **Pipey [EB]**

- Soils with only a Bs horizon.

  **Sesquic [EK]**

- Soils with only a Bhs horizon.

  **Humosesquic [CO]**

- Soils with a Bhs/Bs horizon.

  **Humosesquic/Sesquic [IG]**

**Semiaquic Podosols**

- Soils with a pipey B horizon.

  **Pipey [EB]**

- Soils with only a Bs horizon.

  **Sesquic [EK]**

- Soils with only a Bhs horizon.

  **Humosesquic [CO]**

- Soils with only a Bh horizon.

  **Humic [CG]**

- Soils with a Bh/Bs horizon.
PODOSOLS

**Humic/Sesquic [CJ]**
- Soils with a Bh/Bhs horizon.

**Humic/Humosesquic [CI]**
- Soils with a Bh/Basi horizon.

**Humic/Alsilic [IH]**
- Soils with a Bh/Basi horizon.

**Aquic-Sulfuric, Aquic-Hypersulfidic and Aquic Podosols**
- Soils with only a Bh/Basi horizon.

**Humic [CG]**
- Soils with a Bh/Basi horizon.

**Humic/Alsilic [IH]**
- Soils with a Bh/Basi horizon.

**Comment**
In the soils classified the most common class in the Aeric Suborder is the Sesquic Great Group, but Humic is most common in the other two Suborders.

**Subgroups**
Each class listed below may not be relevant for every Great Group of each Suborder.
- Soils with a peaty horizon and a strongly coherent B horizon.
  **Peaty-Parapanic [DX]**
- Soils with a peaty horizon and a thin ironpan that occurs within or directly underlying the B horizon.
  **Peaty-Placic [GD]**
- Other soils with a peaty horizon.
  **Peaty [DW]**
- Soils with a humose horizon and a strongly coherent B horizon.
  **Humose-Parapanic [CN]**
- Other soils with a humose horizon.
  **Humose [CK]**
- Soils with a melacic horizon and a strongly coherent B horizon.
  **Melacic-Parapanic [DJ]**
- Other soils with a melacic horizon.
  **Melacic [DG]**
- Soils with a melanic horizon.
  **Melanic [DK]**
- Soils with a densipan present in the A2 horizon and a thin ironpan that occurs within or directly underlying the B horizon.
Densic-Placic [HN]

- Other soils with a densipan present in the A2 horizon.

Densic [BI]

- Other soils with a thin ironpan that occurs within or directly underlying the B horizon.

Placic [EC]

- Soils with a hard siliceous pan directly underlying the B horizon.

Silpanic [EM]

- Soils with a ferric horizon within the B horizon.

Ferric [BU]

- Other soils with a strongly coherent B horizon.

Parapanic [DV]

- Soils with a weakly coherent B horizon.

Fragic [BY]

Comment

The term 'parapanic' is meant to imply 'pan-like'. Note also that the A1 horizons of many Podosols may have a distinct surface layer of lighter coloured sand with clean quartz grains and discrete lumps of organic matter and charcoal, giving the layer a speckled appearance. Below this layer, a dark A1 horizon may occur. Because the great majority of Australian Podosols have a bleached A2 horizon, this attribute is not used in the classification. Similarly, the great majority have a B horizon pH of less than 5.5, hence acidic Subgroups have not been used.

Family Criteria

Water repellence of surface soil

Non water repellent [NR]: Water absorbed in 10 seconds or less
Water repellent [WR]: Water takes more than 10 seconds and 2 Molar ethanol takes 10 seconds or less to be absorbed into soil.
Strongly water repellent [SR]: 2 Molar ethanol takes greater than 10 seconds or less to be absorbed into soil

A1 horizon thickness, or thickness of organic horizon (O2, P1 or P2) if present

Thin [A]: <0.1 m
Moderately thick [B]: 0.1–<0.3 m
Thick [C]: 0.3–0.6 m
Very thick [D]: >0.6 m

Gravel of the surface and A1 horizon

Non-gravelly [E]: <2%
Slightly gravelly [F]: 2–<10%
Gravelly [G]: 10–<20%
Moderately gravelly [H]: 20–50%
<table>
<thead>
<tr>
<th>Texture</th>
<th>[I]</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very gravelly</td>
<td>&gt;50%</td>
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**A1 horizon texture, or texture of organic horizon (O2, P1 or P2) if present**

<table>
<thead>
<tr>
<th>Texture</th>
<th>Code</th>
<th>Description</th>
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<tr>
<td>Peaty</td>
<td>[J]</td>
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<tr>
<td>Sandy</td>
<td>[K]</td>
<td>S-LS-CS (up to 10% clay)</td>
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<tr>
<td>Loamy</td>
<td>[L]</td>
<td>SL-L (10-20% clay)</td>
</tr>
<tr>
<td>Clay loamy</td>
<td>[M]</td>
<td>SCL-CL (20-35% clay)</td>
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<tr>
<td>Silty</td>
<td>[N]</td>
<td>ZL-ZCL (25-35% clay and silt 25% or more)</td>
</tr>
<tr>
<td>Clayey</td>
<td>[O]</td>
<td>LC-MC-HC (&gt;35% clay)</td>
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**B horizon maximum texture**

<table>
<thead>
<tr>
<th>Texture</th>
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</thead>
<tbody>
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<td>[O]</td>
<td>LC-MC-HC (more than 35% clay)</td>
</tr>
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**Soil depth**

<table>
<thead>
<tr>
<th>Depth</th>
<th>Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very shallow</td>
<td>[T]</td>
<td>&lt;0.25 m</td>
</tr>
<tr>
<td>Shallow</td>
<td>[U]</td>
<td>0.25–&lt;0.5 m</td>
</tr>
<tr>
<td>Moderately deep</td>
<td>[V]</td>
<td>0.5–&lt;1.0 m</td>
</tr>
<tr>
<td>Deep</td>
<td>[W]</td>
<td>1.0–&lt;1.5 m</td>
</tr>
<tr>
<td>Very deep</td>
<td>[X]</td>
<td>1.5–5 m</td>
</tr>
<tr>
<td>Giant</td>
<td>[Y]</td>
<td>&gt;5 m</td>
</tr>
</tbody>
</table>

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1 This refers to the most clayey field texture category.
Rudosols [RU]

[ Pronounced Roo-doh-sols ]

Concept
This Order is designed to accommodate soils that have negligible pedologic organisation. They are usually young soils in the sense that soil forming factors have had little time to pedologically modify parent rocks or sediments. The component soils can obviously vary widely in terms of texture and depth; many are stratified and some are highly saline. Data on some of them are very limited.

Definition
Soil with negligible (rudimentary) pedologic organisation apart from (a) minimal development of an Al horizon or (b) the presence of less than 10% of B horizon material (including pedogenic carbonate) in fissures in the parent rock or saprolite. The soils are apedal or only weakly structured in the A1 horizon and show no pedological colour changes apart from the darkening of an A1 horizon. There is little or no texture or colour change with depth unless stratified or buried soils are present.

Comment
By definition, these soils will grade to Tenosols, so before deciding on the Order check the Tenosol definition as it will often be a matter of judgement as to which Order a particular soil is best placed. Arenic (sandy) Rudosols will grade with Arenosols, although by definition will have sand less than 1 m deep. Hydrosols are excluded on the basis that these will normally show some pedological development e.g. mottling. A particular problem with the definition and subdivision of Rudosols is the difficulty in distinguishing between soil and ‘non-soil’, (see also 'What do we classify?'). In many instances they are classified on the basis of the nature of AC or C horizon materials or other substrates because these are the dominating features of the profile. It also follows that there may be difficulties in deciding if a soil is best classified as an Anthroposol or be regarded as an ‘anthropic’ Rudosol because the little-altered soil parent material may be human-made.

Suborders

- Soils that are not highly saline (EC <2 dSm⁻¹; 1:5 H₂O) and dominantly consist of gypsum crystals that are sand-sized or finer.
  **Hypergypsic [FJ]**

- Soils that are highly saline (EC >2 dSm⁻¹; 1:5 H₂O), often salt-encrusted, frequently stratified, but do not have a permanent or seasonal water table and do not show any evidence, such as mottling, of episodic wetting by groundwater.
  **Hypersalic [CS]**

- Soils that dominantly consist of particles of shells and other aquatic skeletons (identifiable under a 10 x hand lens and often readily visible to the naked eye).
  **Shelly [EL]**

- Soils in which the upper 0.5 m (or less if the profile is shallower) consists dominantly of carbic materials.
Carbic [HG]

... Soils that are underlain within 0.5m of the surface by a calcrete pan; hard unweathered rock or other hard materials; or partially weathered or decomposed rock or saprolite.

Leptic [CY]

... Soils in which the profile is not or only slightly gravelly (<10%, 2 mm) throughout, either loose or only weakly coherent both moist and dry, and the texture is dominantly sandy (i.e. field textures of S-LS-CS) and there is no layer with a clay content of >15% (i.e. field texture of SL+ or heavier). Aeolian cross-bedding may be present but there is little if any evidence of other stratification or buried soils.

Arenic [AO]

... Soils that consist dominantly of unconsolidated mineral materials that are not or only slightly gravelly (<10% >2mm). Aeolian cross-bedding may be present but there is little if any evidence of other stratification or buried soils. If the soil material is sandy (i.e. S-LS-CS, up to 10% clay) it is coherent.

Lutic [GV]

... Soils that consist dominantly of unconsolidated mineral materials that are distinct, not or only slightly gravelly (<10% >2 mm) sedimentary layers or buried soils but salinity is not high (EC <2 dSm⁻¹; 1:5 H₂O).

Stratic [ER]

... Soils that consist dominantly of unconsolidated mineral materials that are gravelly (>10% >2 mm). The gravel may occur as distinct layers, or be uniformly or irregularly distributed.

Clastic [HH]

Comment

The Hypergypsic soils normally occur as gypsum lunettes and the Hypersalic soils are most common in many of the saline playas of the arid interior of the continent. Shelly soils are widespread as coastal and near coastal dunes in southern and south-western Australia. Carbic soils have so far only been recorded in the Sydney basin, NSW. The Arenic Suborder mainly caters for shallow variants of siliceous dunes and sandsheets of arid Australia, and for some usually recently deposited fluvial sands and very young coastal sands such as foredunes. Deeper sands are classified in the Arenosols Order.

The Lutic soils include loamy or clayey aeolian forms common on some of the many lunettes in southern Australia, as well as other coherent soils formed on sandy, loamy or clayey fluvial deposits, or easily weathered rocks. The Stratic and Clastic soils are most common on alluvial terraces, plains and fans.

Great Groups

No Great Groups are presently proposed for the Hypergypsic, Carbic, Lutic or Stratic Suborders as data are very limited.

Hypersalic Rudosols

... Soils in which sulfuric material (at least 15 cm thick) occurs within the upper 1.5m of the profile.
Sulfuric [EV]

Note: The sulfuric Great Group can be replaced by the following Great Group where appropriate evidence is available:

- Soils in which both monosulfidic material and sulfuric material (at least 15 cm thick) occur within the upper 1.5m of the profile.

Monosulfidic-Sulfuric [IW]

- Soils in which sulfidic materials occur within the upper 1.5 m of the profile.

Sulfidic [EU]

Note: The sulfidic Great Group can be replaced by the following Great Groups where appropriate evidence is available:

- Soils in which both monosulfidic material and hypersulfidic material occur within the upper 1.5 m of the profile.

Monohypersulfidic [IX]

- Other soils in which hypersulfidic material occurs within the upper 1.5m of the profile.

Hypersulfidic [IZ]

- Soils in which both monosulfidic material and hyposulfidic material occur within the upper 1.5 m of the profile.

Monohyposulfidic [JA]

- Other soils with hyposulfidic material within the upper 1.5m of the profile.

Hyposulfidic [JC]

- A gypsic horizon occurs within the upper 0.5 m of the profile.

Gypsic [BZ]

- The major part of the upper 0.5 m of the profile consists of materials dominated (>50%) by halite crystals.

Halic [CC]

Shelly Rudosols

- Soils with a coquina substrate

Coquinic [JU]

- The soil material directly overlies a calcrete pan.

Petrocalcic [DZ]

- The soil material directly overlies hard rock.

Lithic [CZ]

- Soils that overlie other unconsolidated mineral materials.

Regolithic [GF]
**Arenic and Leptic Rudosols**

- The soil material directly overlies a red-brown hardpan. **Duric [BJ]**

- The soil material contains a ferric horizon and directly overlies ferricrete, a petroferric horizon or a petroreticulate horizon. **Ferric-Petroferric [GE]**

- The soil material directly overlies ferricrete, a petroferric horizon or a petroreticulate horizon. **Petroferric [EA]**

- The soil material directly overlies a calcrete pan. **Petrocalcic [DZ]**

- Soils that overlie a hard siliceous pan. **Silpanic [EM]**

- The soil material directly overlies hard rock. **Lithic [CZ]**

- The soil material directly overlies partially weathered or decomposed rock or saprolite. **Paralithic [DU]**

- Soils dominated by gritty coarse sand (0.2–2 mm) and, if present, fine gravel (particle size 2-6 mm). Gritty material composed of angular or subangular quartz or other hard rock fragments. **Gritty [JQ]**

**Clastic Rudosols**

- Soils in which the gravel consists dominantly of little-weathered tephric materials. **Tephric [HF]**

- Soils in which the gravelly materials contain a ferric horizon. **Ferric [BU]**

- Soils in which the gravelly materials contain a bauxitic horizon. **Bauxitic [AS]**

- Soils in which the gravel consists of usually unsorted material with a wide size range. It is largely colluvial mass movement debris, including scree and talus, and landslide, mudflow and creep deposits. **Colluvic [HI]**

- Soils in which the gravel consists dominantly of mostly rounded materials that have been transported by streams or by wave action. **Fluvic [BX]**

- Other soils in which the unconsolidated mineral materials are dominated by gravel
which mostly consists of rock or mineral fragments.

Lithosolic [HJ]

Comment
The Tephric soils in the Clastic Suborder are known only from some of the Pliocene to Holocene Newer Volcanics in south western Victoria. They have not weathered sufficiently for them to be recognised as possessing andic properties, or to meet the requirements for the Tenosols.
In the Petrocalcic Great Group of the Leptic Suborder the calcrete occurs as a substrate material that may or may not be the parent material of the soil.

Subgroups
No Subgroups are yet proposed for the Shelly and Carbic Suborders. The following Subgroups will be used for the remaining Suborders where relevant.

- The major part of the soil materials is strongly acid.
  Acidic [AI]

- The soil materials are not calcareous and the major part is not strongly acid.
  Basic [AR]

- At least some part of the soil materials is calcareous.
  Calcareous [BC]

Comment
In the Calcareous Subgroups the carbonate present is usually not pedogenic, but is in effect part of the parent material, either of aeolian or residual origin. However, in Calcarosol landscapes it is inevitable that some young alluvial deposits may contain transported pedogenic carbonate nodules, and hence soils developed on such deposits should be regarded as Rudosols rather than Calcarosols. The presence of sedimentary layering will usually be diagnostic. Small amounts of pedogenic carbonate (<10%) may occur in fissures in the parent rock or saprolite of some Leptic Rudosols.
A similar situation arises in the case of the Calcareous Hypergypsic soils. These usually occur on lunettes, and thus the carbonate is also of aeolian origin. Whether or not pedogenic accumulations also occur will probably depend on the age of the lunettes. If so, the soils will be more appropriately classified as Hypergypsic Calcarosols.

Family Criteria
There are obvious problems in applying the usual Family criteria to Rudosols. By definition, A horizons have minimal development and hence may be difficult to recognise, and in some classes the texture is set by definition, e.g. the Arenic Suborder is sandy. Hence it is thought better to use the term surface soil for texture and to delete the thickness criteria and not refer to any classes for subsoil texture. By definition, subsoil texture must be the same as surface soil unless the profile is stratified, in which case the situation is usually too complex to manage satisfactorily. Gravel content of surface soil can be usefully used for several Suborders. In general, surface soil in this context will probably be in the range of 0.1-0.2 m in thickness.

Water repellence of surface soil
Non water repellent [NR] : Water absorbed in 10 seconds or less
Water repellent [WR] : Water takes more than 10 seconds and 2 Molar ethanol
Strongly water repellent \([\text{SR}]\): 2 Molar ethanol takes greater than 10 seconds or less to be absorbed into soil.

Gravel of the surface (visual estimate)
- Non-gravelly \([\text{E}]\): <2%
- Slightly gravelly \([\text{F}]\): 2–<10%
- Gravelly \([\text{G}]\): 10–<20%
- Moderately gravelly \([\text{H}]\): 20–50%
- Very gravelly \([\text{I}]\): >50%

Surface soil texture
- Peaty \([\text{J}]\): Dominated by organic materials
- Sandy \([\text{K}]\): S-LS-CS (up to 10% clay)
- Loamy \([\text{L}]\): SL-L (10-20% clay)
- Clay loamy \([\text{M}]\): SCL-CL (20-35% clay)
- Silty \([\text{N}]\): ZL-ZCL (25-35% clay and silt 25% or more)
- Clayey \([\text{O}]\): LC-MC-HC (more than 35% clay)

Soil depth
- Very shallow \([\text{T}]\): <0.25 m
- Shallow \([\text{U}]\): 0.25–<0.5 m
- Moderately deep \([\text{V}]\): 0.5–<1.0 m
- Deep \([\text{W}]\): 1.0–<1.5 m
- Very deep \([\text{X}]\): 1.5–5 m
- Giant \([\text{Y}]\): >5 m
Sodosols [SO]

[Pronounced So-doh-sols]

Concept
Soils with strong texture contrast between A horizons and sodic B horizons that are not strongly acid. Australia is noteworthy for the extent and diversity of sodic soils (Isbell 1995).

Definition
Soils with a clear or abrupt textural B horizon and in which the major part of the upper 0.2 m of the B2t horizon (or the major part of the entire B2t horizon if it is less than 0.2 m thick) is sodic and not strongly acid. Hydrosols and soils with strongly subplastic upper B2t horizons are excluded.

Comment
There is convincing evidence from the Riverine Plain of south eastern Australia that soils with sodic clay B horizons (ESP 25-30) that are strongly subplastic behave very differently in terms of permeability to the more commonly found plastic sodic clay B horizons that are characterised by low to very low saturated hydraulic conductivity (McIntyre 1979). It is on this basis that subplastic sodic soils are excluded from Sodosols, because of their very different land use properties.

Strongly acid sodic soils are also excluded from Sodosols because they usually contain appreciable exchangeable aluminium (KCl extractable) and thus should be unlikely to disperse.

It is usually possible to assess, in the field, the likelihood of a soil possessing a sodic B2t horizon. Such a criterion as the presence of a bleached A2 horizon with an abrupt change to a B2t horizon that has columnar or prismatic structure is a useful but not universal guide. A high pHw value (>8.5) suggests sodicity, but the converse is not true. The soapy nature of the bolus produced in field texturing will also often suggest appreciable sodium (and/or magnesium) on the clay exchange complex.

Increasing experience in many parts of Australia is confirming that the Emerson dispersion test (Emerson 1967) and the modified version of Loveday and Pyle (1973) is a reliable guide to sodicity. It can be carried out as a preliminary test in the field, but should always be repeated under the better controlled conditions of the laboratory. In the initial test at least several fragments (each about 0.2 g or about 4-5 mm diameter) are immersed in 100 ml of distilled water. The large water:soil ratio is necessary to remove any salt present in the aggregate. Also for this reason Emerson (1991) suggests that the classification for each test be made after 24 hours. For the remoulded test, use a 5 mm cube that can be obtained from the bolus used for determining field texture. This will be approximately in the plastic limit condition. Note that distilled water should be used to prepare the bolus.

Data from Loveday and Pyle (1973) and unpublished data available to the author suggest that a dispersive soil will usually indicate sodicity, i.e. ESP of 6 or greater. The data of Murphy (1995) indicate that whereas Emerson class 1 and the more strongly dispersive soils of class 2 are a reliable indicator of sodicity, class 3 is a more variable predictor. Emerson classes of 5 or greater or a Loveday and Pyle score of zero strongly suggest soils are non-sodic. There is less evidence that the dispersion tests give a reliable indication of the degree of sodicity; factors such as extent of initial slaking and initial salt content in the aggregates, and the amount of magnesium and amount and form of aluminium on the exchange complex (Emerson 1994), can also influence the rapidity of dispersion. Nevertheless, the data of
Loveday and Pyle measuring dispersion after 2 hours and 20 hours showed that the rate of
dispersion could be used as a guide to ESP. This relationship does not apply to the subplastic
soils of the Riverine Plain where subsoils with an ESP of 25-30 do not disperse unless
remoulded (Blackmore 1976). Other anomalous results occur in a small minority of normal
plastic soils in which dispersion will not occur even after remoulding in spite of an ESP much
greater than 6 and a pH$_w$ as high as neutral. In at least some of these non-dispersive soils the
typical sodic soil morphology is present, i.e. a conspicuously bleached A2 horizon abruptly
overlying a B2t horizon with prismatic or columnar structure, suggesting the low hydraulic
conductivity expected of a sodic B horizon.

**Suborders**

The dominant colour class in the major part of the upper 0.2 m of the B2t horizon (or the
major part of the entire B2t horizon if it is less than 0.2 m thick) is:

- Red.

**Red [AA]**

- Brown.

**Brown [AB]**

- Yellow.

**Yellow [AC]**

- Grey.

**Grey [AD]**

- Black.

**Black [AE]**

**Great Groups**

Some Great Group soils are much more common in certain colour Suborders than others.
The Duric and Pedaric Great Groups are known only from the arid zone, the former being
particularly widespread in Western Australia and the latter in western Queensland and New
South Wales, and in South Australia.

- Soils with a red-brown hardpan either within or directly underlying the B horizon.

**Duric [BJ]**

- Soils with a petroferric horizon within the solum.

**Petroferric [EA]**

- Soils with a B horizon that is not calcareous and that directly overlies a calcrete pan.

**Petrocalcic [DZ]**

- Soils in which the upper 0.2 m of the B2t horizon (or the B2t horizon if it is less than
0.2 m thick) has a strong blocky or polyhedral structure in which average ped size is
usually in the range of 5-20 mm. There is very weak adhesion between peds (when
dry it is very easy to insert a spade into the upper B2t horizon). Salt contents are
usually high, resulting in weak dry strength and a bulk density of about 1.3 t m$^{-3}$ or
less. In some soils the B2t horizons may be weakly subplastic. A common feature (but
not diagnostic) of the overlying A horizons is the presence of a band of vesicular
pores near the surface or on the underside of any surface flake.
Pedaric [BK]

- Soils with fine-earth effervescence (1M HCl) throughout the solum.

Effervescent [IE]

- Soils in which the major part of the upper 0.2 m of the B2t horizon is mottled and has an ESP between 6 and <15.

Mottled-Subnatric [FN]

- Other soils in which the major part of the upper 0.2 m of the B2t horizon has an ESP between 6 and <15.

Subnatric [ES]

- Soils in which the major part of the upper 0.2 m of the B2t horizon is mottled and has an ESP between 15 and 25.

Mottled-Mesonatric [FO]

- Other soils in which the major part of the upper 0.2 m of the B2t horizon has an ESP between 15 and 25.

Mesonatric [DP]

- Soils in which the major part of the upper 0.2 m of the B2t horizon is mottled and has an ESP greater than 25.

Mottled-Hypernatric [FP]

- Other soils in which the major part of the upper 0.2 m of the B2t horizon has an ESP greater than 25.

Hypernatric [CR]

Subgroups

Not every Subgroup defined below will be required or be appropriate for each Great Group of each Suborder. Some possible attributes have not been used for various reasons, e.g. bleaching has not been used because the great majority of soils in the class probably are bleached. Structure has not been used because of the diverse range that is encountered in these particular soils.

- Soils with a humose horizon.

Humose [CK]

- Soils with a melanic horizon and a B horizon in which at least 0.3m has vertic properties.

Melanic-Vertic [DN]

- Other soils with a melanic horizon.

Melanic [DK]

- Other soils with a B horizon in which at least 0.3m has vertic properties.

Vertic [EX]

- Soils with a gypsic horizon within the B or BC horizon.
• Soils with a ferric horizon within the solum.

Gypsic [BZ]

• Soils with a manganic horizon within the solum.

Ferric [BU]

Manganic [DC]

• Soils with a hard siliceous pan in the lower A and/or upper B horizon.

Silpanic [EM]

• Soils with an exchangeable Ca/Mg ratio of less than 0.1 in the major part of the B2t horizon.

Magnesic [DB]

• Soils in which the major part of the B2t horizon is dystrophic.

Dystrophic [AF]

• Soils in which the major part of the B2t horizon is mesotrophic.

Mesotrophic [AG]

• Soils in which the major part of the B2t horizon is eutrophic but the B and BC horizons are not calcareous.

Eutrophic [AH]

• Soils in which the carbonate is evident only as a slight to moderate effervescence (1M HCl), and/or contain less than 2% soft finely divided carbonate, and have less than 20% hard carbonate nodules or concretions.

Hypocalcic [CV]

• Soils with a calcareous horizon containing more than 50% of hard calcrite fragments and/or carbonate nodules or concretions and/or carbonate-coated gravel.

Lithocalcic [DA]

• Soils with a calcareous horizon containing 20-50% of hard calcrite fragments and/or carbonate nodules or concretions and/or carbonate-coated gravel.

Supracalcic [FB]

• Soils with a calcareous horizon containing more than 20% of mainly soft, finely divided carbonate, and 0-20% of hard calcrite fragments and/or carbonate nodules or concretions, and/or carbonate-coated gravel.

Hypercalcic [CQ]

• Other soils with a calcareous horizon. (See carbonate classes).

Calcic [BD]

Comment
The calcareous classes above approximately correspond to those of Wetherby and Oades.
(1975) as follows: Hypocalcic - Class IV, Lithocalcic - Class III B and III C, Supracalcic - Class III B, Hypercalcic - Class III A, Calcic - Class I and IIIA. In the Lithocalcic and Supracalcic classes the coarse fragments may be >0.2 m in size and soft carbonate may or may not be present.

**Family Criteria**

**Water repellence of surface soil**

- Non water repellent [NR]: Water absorbed in 10 seconds or less
- Water repellent [WR]: Water takes more than 10 seconds and 2 Molar ethanol takes 10 seconds or less to be absorbed into soil.
- Strongly water repellent [SR]: 2 Molar ethanol takes greater than 10 seconds or less to be absorbed into soil.

**A horizon thickness, or thickness of organic horizon (O2, P1 or P2) if present**

- Thin [A]: <0.1 m
- Moderately thick [B]: 0.1–<0.3 m
- Thick [C]: 0.3–0.6 m
- Very thick [D]: >0.6 m

**Gravel of the surface and A1 horizon**

- Non-gravelly [E]: <2%
- Slightly gravelly [F]: 2–<10%
- Gravelly [G]: 10–<20%
- Moderately gravelly [H]: 20–50%
- Very gravelly [I]: >50%

**A1 horizon texture, or texture of organic horizon (O2, P1 or P2) if present**

- Peaty [J]: Dominated by organic materials
- Sandy [K]: S-LS-CS (up to 10% clay)
- Loamy [L]: SL-L (10-20% clay)
- Clay loamy [M]: SCL-CL (20-35% clay)
- Silty [N]: ZL-ZCL (25-35% clay and silt 25% or more)
- Clayey [O]: LC-MC-HC (>35% clay)

**B horizon maximum texture\(^1\)**

- Clay loamy [M]: SCL-CL (20-35% clay)
- Silty [N]: ZL-ZCL (25-35% clay and silt 25% or more)
- Clayey [O]: LC-MC-HC (more than 35% clay)

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\(^1\) This refers to the most clayey field texture category.
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<th>Soil depth</th>
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<th>Code</th>
<th>Depth Range</th>
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<tbody>
<tr>
<td>Very shallow</td>
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<tr>
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<tr>
<td>Deep</td>
<td></td>
<td>[W]</td>
<td>1.0–&lt;1.5 m</td>
</tr>
<tr>
<td>Very deep</td>
<td></td>
<td>[X]</td>
<td>1.5–5 m</td>
</tr>
<tr>
<td>Giant</td>
<td></td>
<td>[Y]</td>
<td>&gt;5 m</td>
</tr>
</tbody>
</table>
**Tenosols [TE]**

[ Pronounced Ten-oh-sols ]

**Concept**

This Order is designed to embrace soils with generally only weak pedologic organisation apart from the A horizons, excluding soils that have deep sandy profiles with a field texture of sand, loamy sand or clayey sand in 80% or more of the upper 1.0 m. It encompasses a rather diverse range of soils that occur in many parts of Australia.

**Definition**

Soils that do not fit the requirements of any other Soil Orders and generally with one or more of the following:

i. A peaty horizon.

ii. A humose, melagic or melanic horizon, or conspicuously bleached A2 horizon, that overlies a calcrete pan, hard unweathered rock or other hard materials; or partially weathered or decomposed rock or saprolite, or unconsolidated mineral materials.

iii. A horizons that meet all the conditions for a peaty, humose, melagic or melanic horizon except the depth requirement, and directly overlie a calcrete pan, hard unweathered rock or other hard materials; or partially weathered or decomposed rock or saprolite, or unconsolidated mineral materials.

iv. A1 horizons that have more than a weak development of structure and directly overlie a calcrete pan, hard unweathered rock or other hard materials; or partially weathered or decomposed rock or saprolite, or unconsolidated mineral materials.

v. An A2 horizon that overlies a calcrete pan, hard unweathered rock or other hard materials; or partially weathered or decomposed rock or saprolite, or unconsolidated mineral materials.

vi. Either a tenic B horizon, or a B2 horizon with 15% clay (SL) or less\(^1\), or a transitional horizon (C/B) occurring in fissures in the parent rock or saprolite that contains between 10 and 50% of B horizon material (including pedogenic carbonate).

vii. A ferric or bauxitic horizon >0.2 m thick.

viii. A calcareous horizon >0.2 m thick.

**Comment**

It may be desirable to specify a minimum thickness for those A1 horizons that do not meet the requirements for a peaty, humose, melagic or melanic horizon. The inclusion of certain soils with conspicuously bleached A2 horizons may be questioned by some, but it is difficult to find a more appropriate place for them.

The Tenosols will differ from Rudosols by virtue of having either a more than weakly developed A1 horizon, an A2, or a weakly developed B horizon. As B horizons are difficult to identify consistently in some Tenosols, specific mention of a B horizon is omitted from some Suborders. They will obviously grade to Kandosols, and some difficulty may be experienced in separating medium-textured Tenosols from Kandosols. Here again, B horizon

\(^1\) This means that a strongly developed B2w horizon in terms of colour development, is allowed in Tenosols provided the clay content does not exceed 15%.
development is the key; Kandosols must have a clearly distinguishable, well-developed B2 horizon with more than 15% clay. Tenosols will grade to Podosols, but the latter must have a Podosol diagnostic B horizon.

Tenosols also grade to Arenosols but lack the deep sandy horizons characteristic of this Order.

In cold, wet environments, some Tenosols with peaty A horizons will grade to Organosols.

This Third Edition of the Australian Soil Classification removes the Orthic term from the bleached and colour Suborders.

**Suborders**

- **Chernic-Leptic [BF]**

  - Soils with a peaty, humose, melacic or melanic horizon, and are underlain within 0.5 m of the surface by a calcrete pan; hard unweathered rock or other hard materials; or partially weathered or decomposed rock or saprolite. An unbleached A2 horizon may be present between the dark surface horizons and the substrate material.

  - Other soils with a peaty, humose, melacic or melanic horizon. A conspicuously bleached A2 horizon is not present.

  **Chernic [BE]**

  - Soils with a ferric or bauxitic horizon (nodules or concretions) that is at least 0.2 m thick and occupies >50% of the solum depth. The solum depth excludes cemented layers. Genetically these soils may be closely related to Podosols.

  **Sesqui-Nodular [IL]**

  - Soils with a horizon containing more than 20% of fine-earth carbonate that is at least 0.2 m thick.

  **Calcenic [IM]**

  - Soils with a conspicuously bleached A2 horizon, and are underlain within 0.5 m of the surface by a calcrete pan; hard unweathered rock or other hard materials; or partially weathered or decomposed rock or saprolite.

  **Bleached-Leptic [AW]**

  - Other soils that are underlain within 0.5 m of the surface by a calcrete pan; hard unweathered rock or other hard materials; or partially weathered or decomposed rock or saprolite.

  **Leptic [CY]**

  - Soils with a conspicuously bleached A2 horizon.

  **Bleached [GZ]**

The dominant colour class in the major part of the upper 0.5 m of the profile (or the entire profile if it is less than 0.5 m thick) is:

- **Red**

  **Red [AA]**

- **Brown**

  **Brown [AB]**
Yellow [AC]

Grey [AD]

Black [AE]

Great Groups

Chernic-Leptic and Leptic Tenosols

• Soils that overlie a red-brown hardpan.

Duric [BJ]

• Soils that contains a ferric horizon and directly overlies ferricrete, a petroferric horizon or a petroreticulate horizon.

Ferric-Petroferric [GE]

• Soils that overlie ferricrete, a petroferric horizon or a petroreticulate horizon.

Petroferric [EA]

• Soils that overlie a hard siliceous pan.

Silpanic [EM]

• Soils that overlie a calcrete pan.

Petrocalcic [DZ]

• Soils that overlie hard rock.

Lithic [CZ]

• Soils that overlie partially weathered or decomposed rock or saprolite.

Paralithic [DU]

Chernic Tenosols

• Soils that overlie ferricrete, a petroferric horizon or a petroreticulate horizon.

Petroferric [EA]

• Soils that overlie a hard siliceous pan.

Silpanic [EM]

• Soils that overlie a calcrete pan.

Petrocalcic [DZ]

• Soils with a thin ironpan.

Placic [EC]

• Soils that have andic properties and has formed in basaltic tephric materials that may be visibly stratified.
Andic [AK]

- Other soils that have formed in tephric materials that may be visibly stratified.

Tephric [HF]

- Soils with a bauxitic horizon.

Bauxitic [AS]

- Soils with a ferric horizon.

Ferric [BU]

- Soils with a tenic B horizon or a transitional horizon (C/B) occurring in fissures in the parent rock or saprolite that contains between 10 and 50% of B horizon material (including pedogenic carbonate).

Inceptic [IA]

- Soils that overlie hard rock.

Lithic [CZ]

- Soils that overlie partially weathered or decomposed rock or saprolite.

Paralithic [DU]

- Soils that overlie marl.

Marly [DD]

- Soils that overlie other unconsolidated mineral materials.

Regolithic [GF]

Sesqui-Nodular Tenosols

- Soils that overlie a red-brown hardpan.

Duric [BJ]

- Soils that overlie ferricrete, a petroferric horizon or a petroreticulate horizon.

Petroferric [EA]

- Soils that overlie a reticulate horizon.

Reticulate [EF]

- Soils that overlie a hard siliceous pan.

Silpanic [EM]

- Soils that overlie a calcrete pan.

Petrocalcic [DZ]

- Soils with an argic horizon within the solum.

Argic [AP]

- Soils with a tenic B horizon or a transitional horizon (C/B) occurring in fissures in the parent rock or saprolite that contains between 10 and 50% of B horizon material (including pedogenic carbonate).
Inceptic [IA]
• Soils that overlie hard rock.

Lithic [CZ]
• Soils that overlie partially weathered or decomposed rock or saprolite.

Paralithic [DU]
• Soils that overlie other unconsolidated mineral materials.

Regolithic [GF]

Calcenic Tenosols
• Soils that overlie a red-brown hardpan.

Duric [BJ]
• Soils that overlie a hard siliceous pan.

Silpanic [EM]
• Soils that overlie a calcrete pan.

Petrocalcic [DZ]
• Soils with a ferric horizon within the solum.

Ferric [BU]
• Soils that have andic properties and has formed in basaltic tephric materials that may be visibly stratified.

Andic [AK]
• Other soils that have formed in tephric materials that may be visibly stratified.

Tephric [HF]
• Soils with an argic horizon within the solum.

Argic [AP]
• Soils in which the profile is not or only slightly gravelly (2mm) throughout, the soil material is either loose or only weakly coherent both moist and dry, may have aeolian cross bedding, and the texture is dominantly sandy (i.e. field textures of S-LS-CS) in >80% of the profile and no layer with a clay content of >15% (i.e. field texture of SL+).

Arenic [AO]
• Soils that overlie hard rock.

Lithic [CZ]
• Soils that overlie partially weathered or decomposed rock or saprolite.

Paralithic [DU]
• Soils that overlie other unconsolidated mineral materials.

Regolithic [GF]
Bleached-Leptic Tenosols

- Soils that contain a ferric horizon and directly overlies ferricrete, a petroferric horizon or a petroreticulate horizon.

  **Ferric-Petroferric [GE]**

- Soils that overlie ferricrete, a petroferric horizon or a petroreticulate horizon.

  **Petroferric [EA]**

- Soils dominated by gritty coarse sand (0.2–2 mm) and, if present, fine gravel (particle size 2-6 mm) overlying a hard siliceous pan. Gritty material composed of angular or subangular quartz or other hard rock fragments.

  **Gritty-Silpanic [JV]**

- Soils that overlie a hard siliceous pan.

  **Silpanic [EM]**

- Soils that overlie a calcrete pan.

  **Petrocalcic [DZ]**

- Soils in which the A2 horizon contains or overlies a ferric horizon.

  **Ferric [BU]**

- Soils dominated by gritty coarse sand (0.2–2 mm) and, if present, fine gravel (particle size 2-6 mm) overlying hard rock. Gritty material composed of angular or subangular quartz or other hard rock fragments.

  **Gritty-Lithic [JW]**

- Soils that overlie hard rock.

  **Lithic [CZ]**

- Soils dominated by gritty coarse sand (0.2–2 mm) and, if present, fine gravel (particle size 2-6 mm) overlying partially weathered or decomposed rock or saprolite. Gritty material composed of angular or subangular quartz or other hard rock fragments.

  **Gritty-Paralithic [JX]**

- Soils that overlie partially weathered or decomposed rock or saprolite.

  **Paralithic [DU]**

Bleached, Yellow, Red, Brown, Grey and Black Tenosols

- Soils that have a ferric horizon and overlies a red-brown hardpan.

  **Ferric-Duric [FK]**

- Other soils that overlie a red-brown hardpan.

  **Duric [BJ]**

- Soils that contain a ferric horizon and directly overlies ferricrete, a petroferric horizon or a petroreticulate horizon.
**Ferric-Petroferric [GE]**

- Soils that overlie ferricrete, a petroferric horizon or a petroreticulate horizon.

**Petroferric [EA]**

- Soils that overlie a hard siliceous pan.

**Silpanic [EM]**

- Soils that overlie a calcrete pan.

**Petrocalcic [DZ]**

- Soils that contain a ferric horizon and which overlie a reticulate horizon.

**Ferric-Reticulate [IS]**

- Soils that overlie a reticulate horizon.

**Reticulate [EF]**

- Soils with a ferric horizon.

**Ferric [BU]**

- Soils with a bauxitic horizon.

**Bauxitic [AS]**

- Soils that have andic properties and has formed in basaltic tephric materials that may be visibly stratified.

**Andic [AK]**

- Soils that have formed in tephric materials that may be visibly stratified.

**Tephric [HF]**

- Soils with an argic horizon.

**Argic [AP]**

- Soils dominated by gritty coarse sand (0.2–2 mm) and, if present, fine gravel (particle size 2–6 mm). Gritty material composed of angular or subangular quartz or other hard rock fragments.

**Gritty [JQ]**

- Soils in which the profile is not or only slightly gravelly (2mm) throughout, the soil material is either loose or only weakly coherent both moist and dry, may have aeolian cross bedding, and the texture is dominantly sandy (i.e. field textures of S-LS-CS) in >80% of the profile and no layer with a clay content of >15% (i.e. field texture of SL+).

**Arenic [AO]**

- Soils with a tenic B horizon or a transitional horizon (C/B) occurring in fissures in the parent rock or saprolite that contains between 10 and 50% of B horizon material (including pedogenic carbonate).

**Inceptic [IA]**

- Soils that overlie hard rock.
Lithic [CZ]

• Soils that overlie partially weathered or decomposed rock or saprolite.

Paralithic [DU]

• Soils that overlie marl.

Marly [DD]

• Soils in which the B horizon directly overlies other unconsolidated mineral materials.

Regolithic [GF]

Subgroups

These have been grouped into the various Suborders, but not all Subgroups will be appropriate for each Great Group of a particular Suborder.

Subgroups of Chernic-Leptic Tenosols

• Soils with a peaty horizon.
  Peaty [DW]

• Soils with a humose horizon.
  Humose [CK]

• Soils with a melacic horizon.
  Melacic [DG]

• Soils with a melanic horizon.
  Melanic [DK]

Subgroups of Chernic Tenosols

• Soils with a peaty horizon.
  Peaty [DW]

• Soils with a humose horizon and the major part of the B horizon (if present) is strongly acid.
  Humose-Acidic [GY]

• Soils with a humose horizon and at least some part of the B, BC or C/B horizon (if present) is calcareous.
  Humose-Calcareous [GU]

• Other soils with a humose horizon.
  Humose [CK]

• Soils with a melacic horizon and the major part of the B horizon (if present) is not strongly acid but the B and BC or C/B horizons are not calcareous.
  Melacic-Basic [FU]

• Other soils with a melacic horizon.
  Melacic [DG]
• Soils with a melanic horizon and the major part of the B horizon (if present) is strongly acid.

**Melanic-Acidic [FV]**

• Soils with a melanic horizon and at least some part of the B, BC or C/B horizon (if present) is calcareous.

**Melanic-Calcareous [FC]**

• Other soils with a melanic horizon.

**Melanic [DK]**

**Subgroups of Sesqui-Nodular Tenosols**

• Soils with a conspicuously bleached A2 horizon and a manganic horizon within the solum.

**Bleached-Manganic [AY]**

• Other soils with a manganic horizon with the solum.

**Manganic [DC]**

• Soils with a conspicuously bleached A2 horizon.

**Bleached [AT]**

• Soils in which the major part of the solum is strongly acid.

**Acidic [AI]**

• Soils in which the major part of the solum is not strongly acid and no part of the solum is calcareous.

**Basic [AR]**

• Other soils in which at least some part of the solum is calcareous.

**Calcareous [BC]**

**Subgroups of Calcenic Tenosols**

• Soils in which the calcareous horizon contains more than 50% of hard calcrete fragments and/or carbonate nodules or concretions.

**Lithocalcic [DA]**

• Soils in which the calcareous horizon contains 20-50% of hard calcrete fragments and/or carbonate nodules or concretions.

**Supracalcic [FB]**

• Other soils in which the calcareous horizon contains less than 20% of hard calcrete fragments and/or carbonate nodules or concretions.

**Hypercalcic [CQ]**

**Subgroups of Bleached-Leptic Tenosols**

• Soils with a peaty horizon.
Peaty [DW]

- Soils with a humose horizon and the major part of the A2 horizon is strongly acid.

Humose-Acidic [GY]

- Soils with a humose horizon and at least some part of the A2 horizon is calcareous.

Humose-Calcareous [GU]

- Other soils with a humose horizon.

Humose [CK]

- Soils with a melacic horizon and the major part of the A2 horizon is not strongly acid.

Melacic-Basic [FU]

- Other soils with a melacic horizon.

Melacic [DG]

- Soils with a melanic horizon and the major part of the A2 horizon is strongly acid.

Melanic-Acidic [FV]

- Soils with a melanic horizon and at least some part of the A2 horizon is calcareous.

Melanic-Calcareous [FC]

- Other soils with a melanic horizon.

Melanic [DK]

- Other soils in which the major part of the A2 horizon is strongly acid.

Acidic [AI]

- Other soils in which the major part of the A2 horizon is not strongly acid but the A2 horizon is not calcareous.

Basic [AR]

- Other soils in which at least some part of the A2 horizon is calcareous.

Calcareous [BC]

Subgroups of Leptic Tenosols

- Soils with all the requirements for a peaty horizon except the thickness.

Subpeaty [ID]

- Soils with all the requirements of a humose horizon except the thickness.

Subhumose [DR]

- Soils with all the requirements of a melacic horizon except the thickness.

Submelacic [FF]

- Soils with all the requirements of a melanic horizon except the thickness.

Submelanic [FG]
• Soils in which the major part of the solum is strongly acid.  
  **Acidic [AI]**

• Soils in which the major part of the solum is not strongly acid and no part of the solum is calcareous.  
  **Basic [AR]**

• Other soils in which at least some part of the solum is calcareous.  
  **Calcareous [BC]**

**Subgroups of Bleached, Red, Brown, Yellow, Grey and Black Tenosols**

• Soils with a peaty horizon.  
  **Peaty [DW]**

• Soils with a humose horizon and the major part of the A2 horizon is strongly acid.  
  **Humose-Acidic [GY]**

• Soils with a humose horizon and at least some part of the A2 horizon is calcareous.  
  **Humose-Calcareous [GU]**

• Other soils with a humose horizon.  
  **Humose [CK]**

• Soils with a melacic horizon and the major part of the A2 horizon is not strongly acid.  
  **Melacic-Basic [FU]**

• Other soils with a melacic horizon.  
  **Melacic [DG]**

• Soils with a melanic horizon and the major part of the A2 horizon is strongly acid.  
  **Melanic-Acidic [FV]**

• Soils with a melanic horizon and at least some part of the A2 horizon is calcareous.  
  **Melanic-Calcareous [FC]**

• Other soils with a melanic horizon.  
  **Melanic [DK]**

• Other soils with a manganic horizon with the solum.  
  **Manganic [DC]**

• Other soils in which the major part of the solum is strongly acid.  
  **Acidic [AI]**

• Other soils in which the major part of the solum is not strongly acid but the A2 horizon is not calcareous.  
  **Basic [AR]**

• Other soils in which at least some part of the solum is calcareous.
**Calcereous [BC]**

**Family Criteria**

Note that in some Suborders the soil depth may be the same as A1 horizon thickness. In those Suborders it will not be relevant to record maximum B horizon texture.

**Water repellence of surface soil**

<table>
<thead>
<tr>
<th>Classification</th>
<th>Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non water repellent</td>
<td>NR</td>
<td>Water absorbed in 10 seconds or less</td>
</tr>
<tr>
<td>Water repellent</td>
<td>WR</td>
<td>Water takes more than 10 seconds and 2 Molar ethanol takes 10 seconds or less to be absorbed into soil</td>
</tr>
<tr>
<td>Strongly water repellent</td>
<td>SR</td>
<td>2 Molar ethanol takes greater than 10 seconds or less to be absorbed into soil</td>
</tr>
</tbody>
</table>

**A1 horizon thickness, or thickness of organic horizon (O2, P1 or P2) if present**

<table>
<thead>
<tr>
<th>Classification</th>
<th>Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thin</td>
<td>A</td>
<td>&lt;0.1 m</td>
</tr>
<tr>
<td>Moderately thick</td>
<td>B</td>
<td>0.1–&lt;0.3 m</td>
</tr>
<tr>
<td>Thick</td>
<td>C</td>
<td>0.3–0.6 m</td>
</tr>
<tr>
<td>Very thick</td>
<td>D</td>
<td>&gt;0.6 m</td>
</tr>
</tbody>
</table>

**Gravel of the surface and A1 horizon**

<table>
<thead>
<tr>
<th>Classification</th>
<th>Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non-gravelly</td>
<td>E</td>
<td>&lt;2%</td>
</tr>
<tr>
<td>Slightly gravelly</td>
<td>F</td>
<td>2–&lt;10%</td>
</tr>
<tr>
<td>Gravelly</td>
<td>G</td>
<td>10–&lt;20%</td>
</tr>
<tr>
<td>Moderately gravelly</td>
<td>H</td>
<td>20–50%</td>
</tr>
<tr>
<td>Very gravelly</td>
<td>I</td>
<td>&gt;50%</td>
</tr>
</tbody>
</table>

**A1 horizon texture, or texture of organic horizon (O2, P1 or P2) if present**

<table>
<thead>
<tr>
<th>Classification</th>
<th>Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peaty</td>
<td>J</td>
<td>Dominated by organic materials</td>
</tr>
<tr>
<td>Sandy</td>
<td>K</td>
<td>S-LS-CS (up to 10% clay)</td>
</tr>
<tr>
<td>Loamy</td>
<td>L</td>
<td>SL-L (10-20% clay)</td>
</tr>
<tr>
<td>Clay loamy</td>
<td>M</td>
<td>SCL-CL (20-35% clay)</td>
</tr>
<tr>
<td>Silty</td>
<td>N</td>
<td>ZL-ZCL (25-35% clay and silt 25% or more)</td>
</tr>
<tr>
<td>Clayey</td>
<td>O</td>
<td>LC-MC-HC (&gt;35% clay)</td>
</tr>
</tbody>
</table>

**B horizon maximum texture**

<table>
<thead>
<tr>
<th>Classification</th>
<th>Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sandy</td>
<td>K</td>
<td>S-LS-CS (up to 10% clay)</td>
</tr>
<tr>
<td>Loamy</td>
<td>L</td>
<td>SL-L (10-20% clay)</td>
</tr>
<tr>
<td>Clay loamy</td>
<td>M</td>
<td>SCL-CL (20-35% clay)</td>
</tr>
<tr>
<td>Silty</td>
<td>N</td>
<td>ZL-ZCL (25-35% clay and silt 25% or more)</td>
</tr>
<tr>
<td>Clayey</td>
<td>O</td>
<td>LC-MC-HC (more than 35% clay)</td>
</tr>
</tbody>
</table>

**Soil depth**

<table>
<thead>
<tr>
<th>Classification</th>
<th>Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very shallow</td>
<td>T</td>
<td>&lt;0.25 m</td>
</tr>
<tr>
<td>Shallow</td>
<td>U</td>
<td>0.25–&lt;0.5 m</td>
</tr>
<tr>
<td>Moderately deep</td>
<td>V</td>
<td>0.5–&lt;1.0 m</td>
</tr>
<tr>
<td>Deep</td>
<td>W</td>
<td>1.0–&lt;1.5 m</td>
</tr>
<tr>
<td>Very deep</td>
<td>X</td>
<td>1.5–5 m</td>
</tr>
<tr>
<td>Giant</td>
<td>Y</td>
<td>&gt;5 m</td>
</tr>
</tbody>
</table>

\(^2\) This refers to the most clayey field texture category.
Vertosols [VE]

[Pronounced Vert-oh-sols]

Concept

Clay soils with shrink-swell properties that exhibit strong cracking when dry and at depth have slickensides and/or lenticular peds. Although many soils exhibit gilgai microrelief, this feature is not used in their definition. Australia has the greatest area and diversity of cracking clay soils of any country in the world.

Definition

Soils with the following:

1. A clay field texture or 35% or more clay throughout the solum except for thin, surface crusty horizons 0.03 m or less thick and
2. When dry, open cracks occur at some time in most years. These are at least 5 mm wide and extend upward to the surface or to the base of any plough layer, peaty horizon, self-mulching horizon, or thin, surface crusty horizon; and

Slickensides and/or lenticular peds occur at some depth in the solum. See Comment below.

Comment

In some clay soils it may be difficult to decide if sufficient cracks are present, or at the time of inspection the soil may be too moist to exhibit cracking. Also, in arid zone clay soils that commonly have high salt contents, the soil structure may be so fine and strong granular, or ‘puffy’, that it is difficult to decide if cracks are present or not. In such soils it is also obviously difficult to discern slickensides and/or lenticular peds. In yet other clay soils (up to 50% clay or more) cracks may develop but slickensides and/or lenticular peds are apparently not present.

Because cracking, slickensides and/or lenticular peds are essentially used as evidence to indicate shrink-swell behaviour, it is desirable that surrogate measurements be available if the morphological evidence is lacking or cannot be determined. See Vertic properties.

Suborders

... Soils with stagnant water on the soil surface and/or saturation of some part of the upper 0.5 m more or less continuously for prolonged periods in most years. The length of a 'prolonged period' is probably of the order of 2-3 continuous months. Evidence of wetness may be indicated by the presence of mottling and gley colours (chroma of 2 or less).

Aquic [AM]

... The dominant colour class in the major part of the upper 0.5 m of the B2 horizon (or the major part of the entire B2 horizon if it is less than 0.5 m thick) is:

... Red.

Red [AA]

1 Note that there is no crack frequency criterion as in the Factual Key (Northcote 1979)
Brown.

Yellow.

Grey.

Black.

Comment
Of the soils entered in the data base, the most common class was Black (40%) which is probably a reflection of the agricultural importance of these soils.

Great Groups
These may not all apply to each Suborder, in particular our knowledge of the Aquic Suborder is limited.

- Soils with a surface that is moderately to strongly self-mulching; when the soil is dry the self-mulching layer should be at least 10 mm thick. Initial drying may form a thin (2-5 mm) surface flake that readily disintegrates to a mulch on further drying. This process is accelerated by mechanical disturbance.

  Self-mulching [EI]

- Soils with a pedal (stronger than weak grade, blocky or polyhedral) A horizon that is either not or only weakly self-mulching, and there is no surface crusty horizon. Some soils after wetting and drying may form a thin 5-10 mm surface flake that cracks into irregular polygons (plates) 0.03-0.1 m diameter. These may be readily separated and removed from the underlying pedal clay.

  Epipedal [GS]

- Soils with a massive or weakly structured surface crusty horizon 0.03 m or less thick, often of lighter texture (lower clay content) than the underlying pedal clay (blocky or polyhedral) that is not self-mulching.

  Crusty [BH]

- Soils with a massive or weak blocky (usually >0.05 m peds) A horizon, and there is no surface crusty horizon.

  Massive [DF]

- Soils with a surface peaty horizon.

  Peaty [DW]

Comment
Apart from the Peaty forms, each of the above soil surface conditions tends to reform despite cultivation or surface trampling. There may be a problem in identifying the self-mulching condition in periods of initial drying, i.e. in assessing the stability of the surface flake that forms following rainfall. If there is doubt as to whether a soil is self-mulching or has only a
pedal surface, it is suggested that the latter condition be recorded, i.e. use the self-mulching Great Group only for those soils where the condition is not in doubt. It may be difficult to determine the surface condition if a dense grass sward is present. In this situation it will be necessary to look for a patch of bare ground, or even to kill the grass with herbicide and return at a later date. Note also that large soil units bounded by cracks are not considered to be coarse peds. It is usually necessary to examine these soils in the moist state to determine their degree of pedality.

Subgroups

It is thought that the following Subgroups will be required for most of the Suborders and Great Groups. Note that some of the differentiating criteria are not mutually exclusive, and thus sometimes it has been a subjective decision as to which attributes have priority in the key.

- Soils with a seasonal saline water table present in the upper 0.5 m of the profile (water conductivity >2 dSm⁻¹). Salt efflorescence may occur on the surface soil when dry.

  **Salic [EG]**

- Soils in which sulfuric material (at least 15 cm thick) occurs within the upper 1.5m of the profile.

  **Sulfuric [EV]**

Note: The sulfuric Subgroup can be replaced by the following Subgroup where appropriate evidence is available:

- Soils in which both monosulfidic material and sulfuric material (at least 15 cm thick) occur within the upper 1.5m of the profile.

  **Monosulfidic-Sulfuric [IW]**

- Soils in which sulfidic materials occur within the upper 1.5 m of the profile.

  **Sulfidic [EU]**

Note: The sulfidic Subgroup can be replaced by the following Subgroups where appropriate evidence is available:

- Soils in which both monosulfidic material and hypersulfidic material occur within the upper 1.5m of the profile.

  **Monohypersulfidic [IX]**

- Other soils in which hypersulfidic material occurs within the upper 1.5m of the profile.

  **Hypersulfidic [IZ]**

- Soils in which both monosulfidic material and hyposulfidic material occur within the upper 1.5m of the profile.

  **Monohyposulfidic [JA]**

- Other soils with hyposulfidic material within the upper 1.5m of the profile.

  **Hyposulfidic [JC]**

- Soils with a red-brown hardpan either within or directly underlying the B horizon.

  **Duric [BJ]**
• Soils in which the B horizon directly overlies a calcrete pan.

  **Petrocalcic [DZ]**

• Soils in which the upper 0.1 m of the solum is sodic and a gypsic horizon is present within the B or BC horizon.

  **Episodic-Gypsic [GQ]**

• Other soils with a gypsic horizon within the B or BC horizon.

  **Gypsic [BZ]**

• Soils in which the upper 0.1 m of the solum is sodic and the major part of the upper 0.5 m of the solum is strongly acid.

  **Episodic-Epiacidic [EP]**

• Soils in which the upper 0.1 m of the solum is sodic and the major part of the solum below 0.5 m is strongly acid.

  **Episodic-Endoacidic [GG]**

• Soils in which the upper 0.1 m of the solum is sodic and the major part of the upper 0.5 m of the solum is calcareous.

  **Episodic-Epicalcareous [GH]**

• Soils in which the upper 0.1 m of the solum is sodic and the major part of the solum below 0.5 m is calcareous.

  **Episodic-Endocalcareous [GI]**

• Other soils in which the upper 0.1 m of the solum is sodic.

  **Episodic [BN]**

• Soils in which some subsurface horizon within the upper 0.5 m of the solum has an ESP of 15 or greater and the major part of the upper 0.5 m of the solum is strongly acid.

  **Epihypersodic-Epiacidic [CU]**

• Soils in which some subsurface horizon within the upper 0.5 m of the solum has an ESP of 15 or greater and the major part of the solum below 0.5 m is strongly acid.

  **Epihypersodic-Endoacidic [GN]**

• Soils in which the major part of the upper 0.5 m of the solum is strongly acid and mottled.

  **Epiacidic-Mottled [GK]**

• Other soils in which the major part of the upper 0.5 m of the solum is strongly acid.

  **Epiacidic [GA]**

• Soils in which the major part of the upper 0.5 m of the solum is calcareous and the major part of the solum below 0.5 m is strongly acid.

  **Epicalcareous-Endoacidic [GJ]**
• Soils in which the major part of the upper 0.5 m of the solum is calcareous and some subsurface horizon within this depth has an ESP of 15 or greater.

**Epicalcereous-Epihypersodic [FM]**

• Soils in which some subsurface horizon within the upper 0.5 m of the solum has an ESP of 15 or greater and the major part of the solum below 0.5 m is calcareous.

**Epihypersodic-Endocalcareous [GO]**

• Other soils in which some subsurface horizon within the upper 0.5 m of the solum has an ESP of 15 or greater.

**Epihypersodic [BR]**

• Soils in which the major part of the upper 0.5 m of the solum is calcareous and an ESP of 15 or greater occurs in some subhorizon of the solum below 0.5 m.

**Epicalcereous-Epihypersodic [GB]**

• Other soils in which the major part of the upper 0.5 m of the solum is calcareous.

**Epicalcereous [FY]**

• Soils in which the major part of the solum below 0.5 m is strongly acid and mottled.

**Endoacidic-Mottled [GL]**

• Other soils in which the major part of the solum below 0.5 m is strongly acid.

**Endoacidic [BL]**

• Soils in which the major part of the solum below 0.5 m is calcareous and some subhorizon of the solum below 0.5 m has an ESP of 15 or greater.

**Endocalcereous-Endohypersodic [GM]**

• Soils with a ferric horizon within the solum, and in which the major part of the solum below 0.5m has an ESP of 15 or greater.

**Ferric-Endohypersodic [JF]**

• Soils with a manganic horizon within the solum, and in which the major part of the solum below 0.5m has an ESP of 15 or greater.

**Manganic-Endohypersodic [JG]**

• Other soils in which some subhorizon of the solum below 0.5 m has an ESP of 15 or greater.

**Endohypersodic [BP]**

• Soils with a ferric horizon within the solum, and in which the major part of the solum below 0.5m is calcareous.

**Ferric-Endocalcereous [JH]**

• Soils with a manganic horizon within the solum, and in which the major part of the solum below 0.5m is calcareous.

**Manganic-Endocalcereous [JI]**

• Soils in which the major part of the solum below 0.5 m is calcareous and the major part of the upper 0.5 m of the solum is mottled.
**Endocalcareous-Mottled [HE]**
- Other soils in which the major part of the solum below 0.5 m is calcareous.

**Endocalcareous [FZ]**
- Soils in which the major part of the B horizon has an exchangeable Ca/Mg ratio of less than 0.1.

**Magnesic [DB]**
- Soils with a conspicuously bleached A2 horizon.

**Bleached [AT]**
- Other soils with a ferric horizon within the solum.

**Ferric [BU]**
- Other soils with a manganic horizon within the solum.

**Manganic [DC]**
- Other soils in which the major part of the upper 0.5 m of the solum is mottled.

**Mottled [DQ]**
- Other soils in which the major part of the upper 0.5 m of the solum is whole coloured.

**Haplic [CD]**

**Comment**

It should be noted that all the Endoacidic soils classified are also Endohypersodic, with some also being Epihypersodic. Additionally, some Epicalcareous-Epihypersodic soils are Endoacidic at depth. It is not possible to cater for all these combinations.
**Family Criteria**

Because of the uniform clayey nature of these soils and their usual lack of distinct horizonation, several of the usual Family criteria are not appropriate for Vertosols. Field texture in these soils may not be a reliable guide to actual clay content (see NCST 2009), and it may also be difficult to achieve consistent results between operators. Hence it is thought more appropriate to provide for a subdivision of actual clay content as determined by laboratory analysis. The classes used are similar to those used for clayey particle-size classes in Soil Taxonomy. Other criteria used are gravel content of surface and A1 horizon and soil depth.

**Gravel of the surface and A1 horizon**

<table>
<thead>
<tr>
<th>Classification</th>
<th>Symbol</th>
<th>Clay Content</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non-gravelly</td>
<td>[E]</td>
<td>&lt;2%</td>
</tr>
<tr>
<td>Slightly gravelly</td>
<td>[F]</td>
<td>2–&lt;10%</td>
</tr>
<tr>
<td>Gravelly</td>
<td>[G]</td>
<td>10–&lt;20%</td>
</tr>
<tr>
<td>Moderately gravelly</td>
<td>[H]</td>
<td>20–50%</td>
</tr>
<tr>
<td>Very gravelly</td>
<td>[I]</td>
<td>&gt;50%</td>
</tr>
</tbody>
</table>

**Clay content of upper 0.1 m (excluding any crusty horizon)**

<table>
<thead>
<tr>
<th>Classification</th>
<th>Symbol</th>
<th>Clay Content</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fine</td>
<td>[Q]</td>
<td>&lt;45% clay</td>
</tr>
<tr>
<td>Medium fine</td>
<td>[R]</td>
<td>&lt;45 – 60% clay</td>
</tr>
<tr>
<td>Very fine</td>
<td>[S]</td>
<td>&gt;60% clay</td>
</tr>
</tbody>
</table>

**B horizon maximum clay content**

<table>
<thead>
<tr>
<th>Classification</th>
<th>Symbol</th>
<th>Clay Content</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fine</td>
<td>[Q]</td>
<td>&lt;45% clay</td>
</tr>
<tr>
<td>Medium fine</td>
<td>[R]</td>
<td>&lt;45 – 60% clay</td>
</tr>
<tr>
<td>Very fine</td>
<td>[S]</td>
<td>&gt;60% clay</td>
</tr>
</tbody>
</table>

**Soil depth**

<table>
<thead>
<tr>
<th>Classification</th>
<th>Symbol</th>
<th>Depth</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very shallow</td>
<td>[T]</td>
<td>&lt;0.25 m</td>
</tr>
<tr>
<td>Shallow</td>
<td>[U]</td>
<td>0.25–&lt;0.5 m</td>
</tr>
<tr>
<td>Moderately deep</td>
<td>[V]</td>
<td>0.5–&lt;1.0 m</td>
</tr>
<tr>
<td>Deep</td>
<td>[W]</td>
<td>1.0–&lt;1.5 m</td>
</tr>
<tr>
<td>Very deep</td>
<td>[X]</td>
<td>1.5–5 m</td>
</tr>
<tr>
<td>Giant</td>
<td>[Y]</td>
<td>&gt;5 m</td>
</tr>
</tbody>
</table>
Glossary

This glossary does not attempt to define all morphological terms used in the classification. It mainly deals with those that are not defined in the Australian Soil and Land Survey Field Handbook (commonly referred to as the 'Yellow book') (NCST 2009). Where applicable all definitions are consistent with usage in the Field Handbook.

**A horizons**

**A1 horizon**
Mineral horizon at or near the soil surface with some accumulation of humified organic matter. Usually darker than underlying horizon/s.

**A2 horizon**
Mineral horizon having, either alone or in combination, less organic matter, sesquioxides, or silicate clay than immediately adjacent horizons. Usually paler than adjacent horizons.

**Conspicuously bleached A2 horizon**
80% or more of the horizon is bleached. Bleached horizons are defined in terms of Munsell notation for dry soil. For all hues, value 7 or greater and chroma 4 or less. Where adjacent horizons have hues 5YR or redder, value 6 or greater with chroma 4 or less.

**Ap horizon**
A horizon/s where ploughing or other disturbance by humans has occurred. Refer to the Australian Soil and Land Survey Handbook (NCST 2009) for further information.

**Andic properties**
These occur in soils that contain significant amounts of volcanic glass and short-range-order minerals such as allophane. Chemical tests and Soil Taxonomy requirements are given in Soil Survey Staff (1994).

**Argic horizon**
An argic horizon is a subsoil horizon(s) consisting of distinct lamellae, usually 5 to 10 mm thick but occasionally up to 0.1 m or greater. They occur as sharply defined, horizontal to subhorizontal layers that are appreciably more clayey than the adjacent sandy or sandy loam soil material. There may be one or several layers present. Consistence strength is stronger, and colour is usually darker and redder or browner than the adjacent soil. This use of the term 'argic' varies from its use in the World Reference Base (2015). The most common known occurrences are in the mallee dune landscapes of Victoria-South Australia.

**B horizons**
The definition of a B horizon has historically differed between the Australian Soil and Land Survey Handbook (NCST 2009) and the Australian Soil Classification with neither being fully satisfactory. The following amended definition of a B horizon is now adopted in both publications. Horizon in which the dominant feature is one or more of the following:

- An illuvial, residual or other concentration of silicate clay, iron, aluminium, carbonate, gypsum, manganese, or organic material, alone or in combination.

1 This revised definition will be adopted in the next edition of the Australian Soil and Land Survey Handbook.
Maximum development of pedologic organisation as evidenced by a different structure and/or consistence, and/or stronger colours than the A horizon(s) above or any horizon immediately below.

In some shallow, stony soils B horizon material may only be present in fissures within the parent rock or saprolite. In such cases there should be 50% or more (visual abundance estimate) of B horizon material for it to qualify as a B horizon for the purposes of this classification (See also "What do we classify" and transitional horizons).

Note: A B1 horizon is a transitional horizon between A and B, that is dominated by properties characteristic of an underlying B2.

**Base status**

This refers to the sum of exchangeable basic cations (Ca, Mg, K and Na) expressed in cmol (+) kg$^{-1}$ clay. This sum is obtained by multiplying the sum of the reported basic cations (which are determined on a soil fine-earth basis) by 100 and dividing by the clay percentage of the sample.

Where this is not available it may be approximated from the field texture using the figures given on pp. 118-120 of the Field Handbook. Three classes are defined: Dystrophic - the sum is less than 5; Mesotrophic - the sum is between 5 and 15 inclusive; Eutrophic - the sum is greater than 15. An estimate of the sum of basic cations for the B horizon of an individual soil may be obtained from its classification if the B horizon maximum texture is recorded in the Family criteria.

**Bauxitic horizon**

Horizon that contains more than 20% (visual abundance estimate) of bauxite nodules or concretions that are mostly uncemented, and has a minimum thickness of 0.1 m.

**Calcareous**

Presence of carbonate segregations or fine-earth (soil matrix) effervescence with 1M HCl.

**Calcareous horizon**

Horizon that is usually identified as a Bk, BCk, 2Bk or 2BCk horizon, or one containing fragments of a cemented (suffix 'm') equivalent of these horizons. As noted in the Field Handbook (p. 108), the suffix k is usually recorded only if there are more than 10% of the calcareous segregations. However in soil with no carbonate except for one horizon with few (2–10%) segregations, this could be designated with a suffix k. See also calcrete, calcrete pan and cemented pans.

**Calcenic**

The presence of a calcareous horizon (consisting of more than 20% pedogenic carbonate) that is at least 0.2 m thick.

**Calcrete**

In the Field Handbook calcrete is described as both a pan (i.e. a soil horizon, such as Bkm) and as a substrate material. However, the definition is the same in both cases, viz 'any cemented terrestrial carbonate accumulation that may vary significantly in morphology and degree of cementation'. The latter may be regarded as indicating the material must be hard. According to this broad definition, calcrete can obviously encompass a wide range of calcareous material although not the common soft segregations of finely divided carbonate, nor accumulations of pedogenic carbonate in the form of discrete nodules or concretions. Unfortunately, the term has been widely used in southern Australia for an almost infinite variety of forms of calcium carbonate. For the purposes of this classification, the term is used strictly as defined in the Field Handbook. See also calcrete, calcrete pan and cemented pans.
**Calcrete pan**
A moderately, strongly or very strongly cemented layer of calcrete that is either continuous, or if discontinuous or broken, consists of at least 90% of hard calcrete fragments, most of which are more than 0.2 m in smallest dimension.

**Carbic materials**
Organic debris that has accumulated by colluvial and alluvial processes when torrential rain occurs following extensive bushfires. The material has a low bulk density (<1 t m3) and consists of variably carbonised plant remains, ranging from little-altered vegetative material to charcoal and humified plant debris. Small amounts of mineral soil are also usually present. The main difference from organic materials is the much lower degree of plant decomposition, i.e. an absence of material that could be classed as peat.

**Carbonate classes**
The following table is a summary of the classes used in the classification for various kinds and amount of calcium carbonate.

<table>
<thead>
<tr>
<th>Class</th>
<th>Soft Carbonate (%)</th>
<th>Hard Carbonate (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hypocalcic</td>
<td>&gt;0 &amp; &lt;2%</td>
<td>&lt;20%</td>
</tr>
<tr>
<td>Calcic</td>
<td>2–20%</td>
<td>&lt;20%</td>
</tr>
<tr>
<td>Hypercalcic</td>
<td>&gt;20%</td>
<td>&lt;20%</td>
</tr>
<tr>
<td>Supracalcic</td>
<td>≥0%</td>
<td>20–50%</td>
</tr>
<tr>
<td>Lithocalcic</td>
<td>≥0%</td>
<td>&gt;50%</td>
</tr>
</tbody>
</table>

**Cemented pans**
In the Field Handbook a pan is defined as an indurated and/or cemented soil horizon and thus horizons such as Bcm, Bkm and Bqm could be interpreted to represent strongly developed B horizons, with consequent effects on the classification of some soils, e.g. Kandosols and Tenosols. The Field Handbook also recognised that it can be difficult to determine if materials such as calcrete, ferricrete, silcrete etc. are indeed soil horizons or are better identified as substrate materials, i.e. do not show pedological development or are paleo-features.

To avoid the above problem, cemented pans such as calcrete, silcrete, red-brown hardpan, ferricrete, petroferric horizon and petroreticulate are recognised as diagnostic substrate features and hence excluded as criteria of B horizon development. Note that the Podosol diagnostic horizons are not regarded as substrate materials.

**Clear or abrupt textural B horizon**
The boundary between the horizon (normally a B2t) and the overlying horizon (that must be thicker than 0.03 m and is normally an A but occasionally a B1 horizon) is clear, abrupt or sharp and is followed by a clay increase giving a strong texture contrast as per the following guidelines:

a) If the clay content of the material above the clear, abrupt or sharp boundary is less than 20%, (and/or has a field texture of sandy loam or lighter) then the clay content immediately below must be at least twice as high. However, there must be a minimum of 20% clay (and/or a minimum field texture of sandy clay loam) at the top of the B horizon.

b) If the material above the transition has 20% clay or more but less than 35% clay (and/or has a field texture of loam or heavier but lighter than light clay), then the material below must show an absolute increase of at least 20% clay, e.g. 25% increasing clearly, sharply or abruptly to at least 45%, (and/or a field texture of
light medium clay or greater). Note that a clear or abrupt textural change is not allowed within the clay range.

<table>
<thead>
<tr>
<th>Overlying horizon</th>
<th>Option a)</th>
<th>Option b)</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;20% clay (Sandy loam or less)</td>
<td>≥20 to &lt;35% clay (Loam or heavier but lighter than light clay)</td>
<td></td>
</tr>
<tr>
<td>Clear, abrupt or sharp boundary</td>
<td>Clear, abrupt or sharp boundary</td>
<td></td>
</tr>
<tr>
<td>Clay content twice the layer above and ≥20% clay at top of B horizon (Sandy clay loam or heavier)</td>
<td>Increase of at least 20% clay to a minimum of 45% clay (Light medium clay or greater)</td>
<td></td>
</tr>
<tr>
<td>B2t</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sand (&lt;5% clay) over light sandy clay loam or heavier (&gt;20%)</td>
<td>Loam (20–25% clay) over light medium clay or heavier (&gt;40% clay)</td>
<td></td>
</tr>
<tr>
<td>Typical examples</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Loamy sand (~5% clay) over sandy clay loam (~25% clay)</td>
<td>Clay loam (30–35%) over medium to heavy clay (&gt;50–55% clay)</td>
<td></td>
</tr>
</tbody>
</table>

Note: The field textures listed in a) and b) above must be regarded only as guidelines. Some discrepancies may arise in soils with high organic matter, silt, fine sand or soft carbonate contents, and in soils with strongly subplastic B horizons. If there are apparent discrepancies between field texture and laboratory data, the first step is to repeat the assessments if possible. If these remain unchanged the classifiers should use their own judgement based on how they think the soil behaves. In some such cases field textures may be a better guide to soil behaviour than particle size data.

Note also that the above definition is not directly equivalent to that of the duplex primary profile form of the Factual Key (Northcote, 1979).

**Colour classes**
See separate section.

**Coquina**
A detrital substrate consisting of cemented shells or shell particles. The constituents are mechanically sorted (usually by sea waves), transported and often abraded because of transport and sorting. It is a porous and soft, weakly to moderately cemented material. It is not as strongly cemented as a calcrete pan, although it can be considered a form of calcrete. Geologists may describe it as detrital limestone.

**Deflation**
Erosion by wind of loose material from flat areas of dry, unconsolidated sediments such as those occurring in deserts, dry lake beds and floodplains.

**Densipan**
An earthy pan that is very fine sandy (0.02–0.05 mm). Fragments, both wet and dry, slake in water. Densipans are less stable on exposure than underlying or overlying horizons.

**Dystrophic**
Base status is less than 5 cmol (+) kg⁻¹ clay.
**ESP (Exchangeable sodium percentage)**

Since the review by Northcote and Skene (1972), an ESP of 6 has been widely used in Australia as a critical limit for the adverse effects of sodicity. ESP is conventionally defined as exchangeable sodium expressed as a percentage of the cation exchange capacity (CEC) - both usually determined in Australia at pH 7 or 8.5. In acid soils, particularly those with variable charge colloids, CEC at pH 7 or 8.5 will normally be higher than that determined at the soil pH. Hence it is more realistic to determine the effective cation exchange capacity (ECEC) (method 15J1 of Rayment and Lyons 2011), or to use an unbuffered method to determine CEC, and to use these values to calculate ESP in soils with pH around 5.5 or less. See also Comment after definition of Kurosols.

In some dystrophic soils, problems can arise when low levels of exchangeable sodium give rise to relatively high ESP values. In such cases there is insufficient evidence that ESP values greater than 6 have a deleterious effect on soil physical properties equivalent to that in less acid soils with higher base status. Further experience may indicate a need for a minimum level of exchangeable sodium to be introduced.

A related problem is the sensitivity of the analytical procedures when values for exchangeable cations and CEC and ECEC are very low. It is probably not advisable to calculate ESP when the CEC or ECEC is 3 cmol (+) kg\(^{-1}\) or less and/or exchangeable sodium is 0.3 cmol (+) kg\(^{-1}\) or less. As an indicator of sodicity, such calculations are likely to be quite misleading. This particularly applies to sandy soils with low clay content (<10%) (e.g. Arenosols) and soils that have been subject to intense weathering (e.g. many Red Kandosols).

Finally, it must be remembered that the effect of ESP on behaviour such as dispersion is also influenced by other soil properties such as organic matter content, clay mineralogy, cation composition, sesquioxide content, and particularly electrolyte concentration of the soil and of any applied irrigation water.

**Eutrophic**

Base status is greater than 15 cmol (+) kg\(^{-1}\) clay.

**Ferric horizon**

One which contains more than 20% (visual abundance estimate) of ferruginous nodules or concretions that are mostly uncemented, and has a minimum thickness of 0.1 m. Most of the nodules contain at least some manganese, and in some situations the majority (if not all) of the nodules may be transported from elsewhere.

**Ferricrete**

In the Field Handbook ferricrete is described as both a pan (i.e. a soil horizon, such as Bcm) and as a substrate material. However, the definition is the same in both cases viz. ‘indurated material rich in hydrated oxides of iron (usually goethite and hematite) occurring as cemented nodules and/or concretions, or as massive sheets’. This material has been commonly referred to in local usage as laterite, duricrust or ironstone. Indurated blocks or extremely coarse irregular forms (>60 mm) are defined as a petroferric horizon.

**Field texture**

Field texture is a measure of the behaviour of a handful of soil (<2 mm fraction) when moistened and kneaded into a ball and then pressed out between thumb and forefinger.

Field textures may differ from textures derived from laboratory particle size analysis. Discrepancies may arise in soils with high organic matter, silt, fine sand or soft carbonate contents, and in soils with strongly subplastic B horizons.

If there are apparent discrepancies between field texture and laboratory data, the first step is to repeat both assessments if possible. If these remain unchanged the classifiers should use their own judgement based on how they think the soil behaves. In some cases field textures
may be a better guide to soil behaviour than particle size data.

**Fine earth**
The less than 2 mm fraction of the soil, typically obtained by passing soil material through a 2 mm sieve.

**Free iron oxide**
This is ‘pedogenic iron’ formed by weathering of ferrous-containing primary minerals. It is determined by citrate-dithionite extract (Rayment and Lyons 2011 Method 13C1). Citrate-dithionite reacts with secondary crystalline iron oxides (e.g. hematite, goethite, lepidocrocite and maghemite) and poorly crystalline amorphous minerals but not magnetite and ilmenite.

**Fusic material**
A coarse fraction comprising hard, cemented (fused) ceramic-like porous fragments located within ashy material known to be derived from burnt peat. Fusic material was first observed and defined in Iraq by Fitzpatrick et al. (2004) and more recently in a range of burnt inland acid sulfate soil profiles in the lower Murray-Darling Basin by Grealish et al. (2010).

**Gley colours**
Greyish, greenish and bluish colours found in wet soils and defined by specific Munsell charts - usually 10Y–5GY and Gley charts 1 & 2.

**Grade of pedality**
Refers to the degree of development and distinctness of peds (natural structural aggregates). It is the proportion of the soil that holds together as entire peds when displaced and the ease with which the soil breaks into discrete peds.

**Grades:**

- **Apedal**
  - Single grain - loose, incoherent mass of individual particles. When displaced, the soil separates into ultimate particles.
  - Massive - coherent. When displaced, the soil separates into fragments that may be crushed into ultimate particles.

- **Pedal**
  - Weak - peds indistinct and barely observable in undisplaced soil. When displaced, up to 1/3 of soil material consists of peds.
  - Moderate - peds well formed and evident but not distinct in undisplaced soil. When displaced more than 1/3 but less than 2/3 of soil material consists of peds.
  - Strong - peds quite distinct in undisplaced soil. When displaced more than 2/3 of soil material consists of peds.

More details are found in the Australian Soil and Land Survey Field Handbook (NCST 2009).

**Gravel**
Gravel is part of the coarse fraction that is 2–60 mm in size. Gravels may be subdivided into 3 sizes classes - fine gravel (2–6 mm), medium gravel (6–20 mm) and coarse gravel (20–60mm). Gravels include hard (when moist) coarse non-pedogenic particles (coarse fragments in the Australian Soil and Land Survey Field Handbook, NCST 2009) and segregations of pedogenic origin. The most common examples of the latter are carbonate and ferruginous nodules and/or concretions.
Gypsic horizon
One which contains more than 20% of visible gypsum that is apparently of pedogenic origin, and has a minimum thickness of 0.1 m. Where the upper boundary of the gypsic horizon first occurs below 1 m depth it is disregarded in the classification.

Hard
In the classification hard is used as a general term to indicate strength. Hard nodules or segregations means their strength is such that they cannot be broken between the thumb and forefinger; i.e. strong in the Field Handbook (p. 198). When referring to pans hard means moderately cemented or stronger (Field Handbook p. 192). When referring to substrate material hard means moderately strong or stronger (Field Handbook p. 209).

Human activities
Activities by humans that have caused a profound modification, mixing, truncation or burial of the original soil horizons, or the creation of new soil parent materials. Examples include middens, additions of excessive organic wastes, land fill, dredge materials, and artificial soils and surface exposures created by earthmoving equipment. Normal agricultural operations, including cultivation, deep ripping, land planing, artificial drainage and flooding, are excluded.

Humose horizon
This is a humus-rich surface or near surface horizon that is 0.2 m or more thick and has insufficient organic carbon to qualify as organic material. The average value for the humose horizon is more than 4% organic carbon [Walkley-Black x 1.3 or a total combustion method (Rayment and Lyons 2011, Methods 6A1 or 6B2).] (but less than 12%) if the mineral fraction contains no clay, or 6% or more organic carbon (but less than 18%) if the mineral fraction contains 60% or more clay; with proportional contents of organic carbon between these limits (see Fig. 2). Approximate loss-on-ignition values are given under organic materials below. This definition is based on that used in England and Wales (Avery 1990).

If the humose surface layer is less than 0.2 m it will not be specifically recognised as a separate texture at the Family level but will be assigned to the relevant mineral soil texture class e.g. sandy, loamy, etc. The one exception occurs in the Leptic Tenosols where a subhumose Subgroup is provided.
Hypersulfidic material
Of the three kinds of sulfidic materials, hypersulfidic material is capable of the most severe acidification as a result of sulfide oxidation. Hypersulfidic material has a field pH of 4 or more and is identified by experiencing a substantial\(^2\) drop in pH to 4 or less (1:1 by weight in water, or in a minimum of water to permit measurement) when a 2–10 mm thick layer is incubated aerobically at field capacity. The duration of the incubation is either: a) until the soil pH changes by at least 0.5 pH unit to below 4, or b) until a stable\(^3\) pH is reached after at least 8 weeks of incubation. This material is commonly referred to as acid sulfate soil.
Hypersulfidic material should have a positive net acidity using acid-base accounting approaches (Ahern et al. 2004). The general form for sulfidic materials is:
Net acidity = Potential sulfidic acidity + Existing acidity - Acid neutralising capacity
The hydrogen peroxide field test (Ahern et al. 2004) may be used as a field indicator of hypersulfidic material (confidence level 3) but confirmation of this classification requires incubation testing (confidence level 1).

Hyposulfidic material
Of the three kinds of sulfidic materials, hyposulfidic material is intermediate to weak in its degree of acidification as a result of sulfide oxidation. Hyposulfidic material: (i) has a field pH of 4 or more and (ii) does not experience a substantial\(^1\) drop in pH to 4 or less (1:1 by weight in water, or in a minimum of water to permit measurement) when a 2–10 mm thick layer is incubated aerobically at field capacity. The duration of the incubation is until a stable\(^2\) pH is reached after at least 8 weeks of incubation.
Hyposulfidic material should have a zero or negative net acidity using acid-base accounting approaches (Sullivan et al. 2018). The general form for sulfidic materials is:
Net acidity = Potential sulfidic acidity + Existing acidity - Acid neutralising capacity.
The field pH peroxide test (Ahern et al. 2004) may be used as a field indicator of hyposulfidic material (confidence level 3) but confirmation of this classification requires incubation testing (confidence level 1). In combination with a positive test of the fine-earth as calcareous (the effervescence test, Ahern et al. 2004), assignation of a confidence level of 2 is reasonable.

Major part
The requirement must be met over more than half the specified thickness.

Manganic horizon
One which contains more than 20% (visual abundance estimate) of black manganiferous nodules or concretions that are mostly uncemented, and has a minimum thickness of 0.1 m. Most nodules also contain some iron.

Marl
A loose, earthy material consisting chiefly of an intimate mixture of clay and calcium carbonate, commonly formed in freshwater lakes. The carbonate content may range from about 30 to 90% (Bates and Jackson 1987).

Mean Low Water Springs (MLWS)
The average of all low water observations at the time of the spring tides over a period of time, preferably 19 years. Click here to see tidal interface compendium of terms

\(^2\) A substantial drop in pH arising from incubation is regarded as an overall decrease of at least 0.5 pH unit
\(^3\) A stable pH is assumed to have been reached after at least 8 weeks of incubation when either the decrease in pH is <0.1 pH unit over at least a 14 day period, or the pH begins to increase.
**Melanic horizon**

This is a dark surface or near surface horizon that has insufficient organic carbon to qualify as a humose horizon, and has little if any evidence of stratification. It has all of the following properties:

1. moist colour is black throughout (i.e. value 3 or less and chroma 2 or less - see Colour classes) and dry colour value is 5 or less.
2. a minimum thickness of 0.2 m (in soils with a clear or abrupt textural B horizon the minimum thickness must be present within the A horizon)
3. the major part of the horizon has more than a weak grade of structure in which the most common ped size is 10–20 mm or less. This condition may be waived for an Ap horizon or when dry consistence strength is weak or less.
4. pH (1:5 H\textsubscript{2}O) is 5.5 or greater throughout the major part of the horizon.

**Melacic horizon**

As for melanic horizon but pH (1:5 H\textsubscript{2}O) is less than 5.5 and there is no structure requirement.

**Mesotrophic**

Base status is between 5 and 15 cmol (+) kg\textsuperscript{-1} clay inclusive.

**Mottled horizon**

An horizon in which mottle abundance is greater than 10% (visual abundance estimate) and contrast between colours is distinct to prominent. Colour patterns due to biological or mechanical mixing, and inclusions of weathered substrate materials, are not included. As pointed out (see Comment - Hydrosols), mottling does not necessarily imply that oxidising and reducing conditions are currently occurring in the soil in most years.

**Monosulfidic materials**

Of the three kinds of sulfidic materials, monosulfidic material is the only one that contains high concentrations of detectable monosulfides (≥0.01% acid volatile sulfide). Monosulfidic material is conceptually similar to Monosulfidic Black Ooze [MBO (Sullivan et al. 2002)]. However, it differs from MBO in that monosulfidic material encompasses a wider array of soil textures and consistencies. For example, monosulfidic material includes sands with >0.01% acid volatile sulfide, that are excluded (on the basis of soil consistence) from being MBOs.

Field identification features for monosulfuric material include: (i) complete saturation; (ii) an ooze-like consistency and low bulk density (for non-sands); (iii) a change in colour on exposure from black (dark) to greyish (lighter) colours; (iv) the lead acetate test paper for hydrogen sulfide, and (v) a "rotten egg" smell of hydrogen sulfide using the so-called 'whiff test' of Darmody et al., (1977) (Caution: hydrogen sulfide is a toxic gas and care should be taken with this test - a broad sweep of the hand to the nose in the open air whilst approaching a small sample of the material is commonly used).

**Organic materials**

These are plant-derived organic accumulations that are either:

1. saturated with water for long periods or are artificially drained and, excluding live plant tissue, (i) have 18% or more organic carbon [Walkley-Black x 1.3 or a total combustion method. (Rayment and Lyons 2011, Methods 6A1 or 6B2).] if the mineral fraction is 60% or more clay, (ii) have 12% or more organic carbon if the mineral fraction has no clay, or (iii) have a proportional content of organic carbon between 12 and 18% if the clay content of the mineral fraction is between zero and 60% (see Fig. 2); or
2. saturated with water for no more than a few days and have 20% or more organic carbon.

This definition is the same as that used in Soil Taxonomy and is very similar to that used in England and Wales (Avery 1990).

Loss-on-ignition (LOI) may be used as an estimate of organic carbon. For non-calcareous soils, the relationship between organic carbon and LOI was found by Spain et al. (1982) to be influenced by clay content. For the range of organic carbon contents of interest, approximate conversions are:

<table>
<thead>
<tr>
<th>Clay (%)</th>
<th>LOI</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;20%</td>
<td>LOI = 2.0 x organic carbon</td>
</tr>
<tr>
<td>20–60%</td>
<td>LOI = 2.3 x organic carbon</td>
</tr>
<tr>
<td>&gt;60%</td>
<td>LOI = 2.7 x organic carbon</td>
</tr>
</tbody>
</table>

**Peat**

As noted in the Field Handbook, peats may be assessed by examining the degree of decomposition and distinctness of plant remains. This may be assisted by using a modification of the von Post field test (see Avery, 1990 p.90), in which a sample of the wet peat is squeezed in the closed hand and the colour of the liquid expressed, the proportion extruded between the fingers, and the nature of the plant residues are observed.

**Fibric Peat.** Undecomposed or weakly decomposed organic material; plant remains are distinct and identifiable; yields clear to weakly turbid water; no peat escapes between fingers.

**Hemic Peat.** Moderately to well-decomposed organic material; plant remains recognisable but may be rather indistinct and difficult to identify; yields strongly turbid to muddy water; amount of peat escaping between fingers ranges from none up to one-third; residue is pasty.

**Sapric Peat.** Strongly to completely decomposed organic material; plant remains indistinct to unrecognisable; amounts ranging from about half to all escape between fingers; any residue is almost entirely resistant remains such as root fibres and wood.

**Peaty horizon (P and O2 horizons in Australian Soil and Field Handbook)**

This is a surface or near surface layer of organic materials at least 0.2 m thick overlying mineral soil and which does not qualify as an Organosol. Such soils are designated as a peaty Subgroup. In cases where the soil has a surface layer of organic materials less than 0.2 m thick but does not qualify for an Organosol (e.g. as in Definition (ii) of Organosols), it will be recognised at the Family level as having a peaty 'texture'. The one exception occurs in the Leptic Tenosols where a subpeaty Subgroup is provided. In the peaty and subpeaty Subgroups there will be a repetition of texture at the Family level.

**Pedologic organisation**

This is a broad term used to describe soil formation, which includes all changes in soil material resulting from the effect of physical, chemical and biological processes. Results of these processes include horizonation, colour differences, presence of pedality and texture and/or consistence changes.

**Petroferric horizon**

Ferruginous, ferromanganiferous or aluminous nodules or concretions cemented in place into indurated blocks or extremely coarse irregular pieces (>60 mm). This horizon is commonly referred to as ferricrete.

**Petroreticulate horizon**

A reticulate horizon (see below) that is always indurated in the greater part both before and after exposure.
**pH**

Unless otherwise specified, pH refers to 1:5 H$_2$O ($pH_w$). Approximate equivalents for $pH_w$ and $pH_{Ca}$ (1:5 soil: 0.01M CaCl$_2$) for the critical pH values used in the classification are as follows:

(based on regressions given by Ahern et al. (1995) for large numbers of Queensland surface and subsoil samples)

- $pH_w$ of 5.5 is approximately equivalent to $pH_{Ca}$ of 4.6
- $pH_w$ of 4.0 is approximately equivalent to $pH_{Ca}$ of 3.5

**Podosol diagnostic horizons**

The various B horizons defined below consist of illuvial accumulations of amorphous organic matter-aluminium and aluminium-silica complexes, with or without iron in various combinations. Although some may qualify as cemented pans, they are not to be regarded as substrate materials.

**Bs horizons.** The usually bright colours indicate that iron compounds are strongly dominant or co-dominant and there is little evidence of organic compounds, apart from a few usually discontinuous patches in the upper B horizon or a thin band (<0.05 m thick) at the A2/B junction. The upper boundary of the B horizon may be very uneven but otherwise the horizons are relatively uniform laterally. Iron concentrations may increase or decrease with depth. No strongly coherent Bs horizons have been recorded. Bs horizons may be non-reactive or give only a weak response to the reactive aluminium test. As a guide, Bs horizons usually have a hue of 5, 7.5 or 10YR, a value of 4 or 5, and a chroma of 4–8. The main feature distinguishing a Bs horizon from a tenic B horizon is some weak and irregular development of organic accumulations that extend laterally although discontinuously. Note that the presence of a thin ironpan (placic horizon), which will be designated as Bsm, is not to be regarded as a Podosol diagnostic horizon because it may also occur in the B horizon of other soils, e.g. Tenosols and Kandosols, and may also be present in C horizons or even parent rocks.

**Bhs horizons.** Iron and organic compounds are both prominent with the organic compounds distributed as streaks, patches or lumps so that concentrations of iron, aluminium and organic compounds have marked spatial variation. Such horizons may contain firm lumps of organic compounds but otherwise are weakly coherent and highly permeable, or they may be strongly coherent throughout, or contain strongly coherent subhorizons or pans. Bhs horizons always contain significant amounts of oxalate-extractable iron and aluminium and frequently silica, i.e. imogolite-allophane complex is usually present in significant amounts and the horizons give a moderate to very strong response to the reactive aluminium test. As a guide, Bhs horizons usually have a hue of 2.5YR to 10YR, and value/chroma of 3/3, 3/4, 3/6, 4/3 or 4/4.

**Bh horizons.** Organic-aluminium compounds are strongly dominant with little or no evidence of iron compounds. Such horizons have a uniform appearance laterally and are relatively uniform vertically although concentrations of carbon and aluminium and the degree of coherence or cementation may change with depth. The horizons may be weakly or strongly coherent, or contain strongly coherent or cemented sub-horizons or pans, or overlie other kinds of pans or clay D horizons. Bh horizons are non-reactive or give only a weak response to the reactive aluminium test. Colours are usually dark with values <4 and chromas <3. In typical Bh horizons the sand grains are uncoated and the organic-aluminium complex is precipitated between the grains (Farmer et al. 1983).

**Bh/Bhs horizons.** These have a subhorizon, dominated by organic and aluminium compounds with relatively low iron (Bh), overlying the major horizon with prominent organic and iron compounds (Bhs). The dark horizon (Bh) may undulate but is usually discontinuous, and rests on or grades into a Bhs with a range in consistence as described above.

**Bh/Bs horizons.** The dark Bh horizon may be weakly or strongly coherent, but is usually
discontinuous and grades quickly to a brightly coloured and weakly coherent Bs horizon.

**Basi horizons.** These are brown, yellow-brown or pale brown cemented horizons that immediately underlie Bh horizons in some poorly drained Podosols. Despite their colour these horizons have low contents of acid oxalate-extractable iron but significant amounts of oxalate-extractable aluminium and silica. The cementing agency appears to be an imogolite-allophane complex with some organic-aluminium compounds. These horizons give a rapid strong or very strong response to the reactive aluminium test. Because of their bright colour and cementation many of these horizons have been included as ortstein in the past.

Bh/Basi horizons. Typical Bh horizons dominated by organic-aluminium compounds that may be weakly coherent or cemented and overlie a cemented Basi horizon.

**Pipey B horizons** are characterised by pipes of bleached A2 horizon that penetrate both vertically and sometimes laterally >50 cm into the B horizon, giving a tongued boundary on a profile face. The pipes are usually enclosed by dark organic compounds forming the pipe walls of Bh or Bh/Bhs materials that usually have a weak to firm consistence strength (i.e. force 2–3) and are brittle when dry. The bleached A2 material consists of clean quartz grains that have lost any oxide coatings. In ‘giant’ Podosols the pipes may penetrate >6 m into the B horizon.

**Reactive aluminium test (Hewitt 1992).**

This test indicates the presence of reactive hydroxy-aluminium groups, as occur for example in allophane and aluminium-humus complexes (Milne et al. 1991). Using the procedure of Fieldes and Perrott (1966), 1 drop of saturated sodium fluoride solution is placed on a small test sample of soil, which has been smeared on to a filter paper treated with phenolphthalein indicator. The soil sample must be field moist. For classification, the reactivity of the soil sample is placed into one of the following classes.

<table>
<thead>
<tr>
<th>Reactivity Class</th>
<th>Class Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 non-reactive</td>
<td>No colour within 2 minutes.</td>
</tr>
<tr>
<td>1 very weak</td>
<td>Pale red or light red (5R 6/1) just discernible within 2 minutes.</td>
</tr>
<tr>
<td>2 weak</td>
<td>Pale red or light red (5R 6/1) within 1 minute.</td>
</tr>
<tr>
<td>3 moderate</td>
<td>Red or weak red (5R 4 or S/-) within 1 minute.</td>
</tr>
<tr>
<td>4 strong</td>
<td>Dusky red or dark red (5R 3/-) after 10 seconds.</td>
</tr>
<tr>
<td>5 very strong</td>
<td>Dusky red or dark red (5R 3/-) within 10 seconds.</td>
</tr>
</tbody>
</table>

**Red-brown hardpan**

An earthy pan that is normally reddish brown to red with a dense yet porous appearance. It is very hard, has an irregular laminar cleavage and some vertical cracks, and varies from less than 0.3 m to over 30 m thick. Wavy black veining, probably manganiferous, are a consistent feature while other more variable features include bedded and unsorted sand and gravel lenses and, less commonly, off-white veins of calcium carbonate. The red-brown hardpan appears to occur either as a cemented sediment or a cemented palaeosol (Wright 1983). It is one of a variable group of silica pans generally known as duripans (Soil Survey Staff 1994) that commonly occur in currently arid climates.

**Reticulate horizon**

A strongly developed reddish, yellowish and greyish or white, more or less reticulately mottled horizon that can be hand-augered or cut with a spade. Ferruginous nodules or concretions may be present but are not diagnostic. When moist, the material usually has at least a firm consistence strength, but following exposure the material may irreversibly harden. At depth it may grade into mottled saprolite.

**Slickensides and/or lenticular peds**

Slickensides are shrink-swell shear features (e.g. grooves, striations, glossy surfaces) on ped faces. Lenticular peds are overlapping, lens-shaped peds that are thick at the centre and taper towards the edges.
**Sodic**
The ESP of the fine-earth soil material is 6 or greater.

**Soil depth**
One of the most important features of a soil is its depth or thickness, but it is frequently difficult to determine the lower limit of soil. For many purposes, depth of soil is considered to be synonymous with the rooting depth of plants, but because this may vary widely it is not always a suitable criterion. Thickness of solum (A + B horizon) is a measure that is useful in many soils, although it may be difficult in some soils to distinguish B from C horizon.

In soils underlain by unconsolidated materials, the unconsolidated materials can be included in soil depth calculations.

At the Family level, soil depth will be taken to mean either thickness of the soil profile or depth to cemented pans, other cemented materials, rock or saprock. In a particular soil it will be evident from the classification which criterion is used. However, depth to a thin ironpan will not be used because of the extremely irregular and convoluted nature of most such pans.

**Soil profile**
A general term for a vertical section of soil from the surface through all its horizons to parent material, other consolidated substrate material or selected depth in unconsolidated material. Compare with solum.

**Solum**
The surface and subsoil layers that have undergone the same soil forming conditions. In terms of soil horizon designations, a solum consists of A and B horizons and their transitional horizons and P and O2 horizons. A solum does not have a maximum or a minimum thickness. Compare with soil profile. Plural sola.

**Strongly acid**
\[ \text{pH}_{w} (1:5 \text{ H}_{2}\text{O}) \text{ is less than 5.5 or} \]
\[ \text{pH}_{Ca} (1:5 \text{ soil : 0.01M CaCl}_{2}) \text{ is less than 4.6.} \]
\[ \text{pH}_{w} < 5.5 \text{ should be used as the critical limit when it is available.} \]

**Strongly coherent B horizon**
These are Podosol B horizons in which the consistence strength ranges from very firm to strong throughout (i.e. force 4-5), or they contain subhorizons with these properties. Included are pan-like materials that have been variously described as ortstein, coffee rock or sandrock. The consistence properties are usually independent of soil water status.

**Subaqueous soil**
This is submerged soil material that may occur in both inland and tidal settings. With Australia’s seasonal climate some inland forms may experience rare periods of exposure during extreme drought. For soil materials exposed more frequently than 1 year in 9, on average however, the definition does not apply; more frequent drought-induced exposed lake beds and wetlands do not classify as Subaqueous.

Sediments in shallow water environments undergo soil forming processes (Demas and Rabenhorst 1999, 2001), are capable of supporting rooted plants, and meet the definition of pedologic organisation used in the ASC to distinguish soil material.

The depth range of the water column where these soils may be found is not known, and an arbitrary depth of 2.5 meters below the surface or MLWS is used. This aligns closely with the definitions of subaqueous and submerged soils adopted by the USDA.
**Subplastic**
Field texture increases 1 to 2 texture groups after 10 minutes kneading.

**Strongly subplastic**
Field texture increases greater than 2 texture groups after 10 minutes kneading.

**Subtidal soil**
This is permanently saturated Subaqueous soil material bordering intertidal flats or other coastal features adjacent to MLWS (e.g. beaches, dunes, headlands).

**Sulfidic materials**
These are soil materials containing detectable inorganic sulfides (≥ 0.01% sulfidic sulfur) that can exist as horizons or layers at least 0.03 m thick or as surficial features. The laboratory measurements of sulfidic sulfur include elemental sulfur as well as various iron sulfide minerals such as pyrite, greigite, mackinawite, marcasite, iron (II) sulfide and pyrrhotite. Ahern et al., (2004) describe a range of methods used in Australia and their applicability. The preferred laboratory method for dry soil samples is the chromium reducible method (SCR) (Sullivan et al. 2000). Where monosulfidic material is suspected, the samples should be analysed using the chromium reducible method in field condition with minimal disturbance arising from storage, desiccation etc.

Sulfidic materials accommodate: (i) a diverse range of seasonally or permanently waterlogged soil materials, and (ii) materials that are almost entirely formed under anaerobic conditions (i.e. experience a reducing environment for all or part of the period of saturation). It is usually possible to assess in the field, the likelihood of soil layers or horizons possessing certain types of sulfidic materials by using surrogate criteria with "Confidence Levels of Classification".

Extensive revisions of the Australian classification of sulfidic materials have been proposed by Sullivan et al., (2010) and there is considerable diversity of opinion on the desirability, nature and efficacy of detailed chemical criteria to define sulfidic materials. For this reason Soil Taxonomy (Soil survey Staff 2010) and the World Reference Base (2006) have deliberately avoided the use of chemical (e.g. Acid Base Accounting) and mineralogical criteria. However, this broad definition of sulfidic materials is deliberately general in nature.

Three kinds of sulfidic materials are distinguished, based essentially on the specific nature and amounts of the various oxidisable sulfur minerals present and the neutralizing capacity of the material. The three kinds defined elsewhere in the Glossary are: (i) hypersulfidic material, (ii) hyposulfidic material and (iii) monosulfidic material.

**Sulfuric material**
Soil material that has a pH less than 4 (1:1 by weight in water, or in a minimum of water to permit measurement) when measured in dry season conditions as a result of the oxidation of sulfidic materials (defined above). Evidence that low pH is caused by oxidation of sulfides is one of the following:

a) yellow mottles and coatings of jarosite (hue of 2.5Y or yellower and chroma of about 6 or more); or
b) underlying sulfidic material.

**Tenic B horizon**
A usually weakly developed B2t, B2w or other B horizon (in terms of contrast between A horizons above and adjacent horizons below) of texture and/or colour and/or structure and/or presence of segregations of pedogenic origin (including carbonate). It usually is

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4 This definition is similar to that in Soil Taxonomy (Soil Survey Staff, 1999) but modified slightly by Dr David Dent, Sullivan et al. (2010) and colleagues in CSIRO.
slightly different from the underlying horizon (excepting buried soils) in terms of a higher chroma, redder hue or higher clay content, but structure should be no more than weak grade and mottles or sesquioxidic segregations of pedogenic origin other than hard ferromanganiferous nodules or concretions should not exceed 10% in the major part of the horizon.

In many shallow stony soils, the tenic B horizon may be present only between rock fragments or in rock fissures (50% or more by visual abundance estimate). Where present in soils formed from sediments, weak evidence of stratification may be present. Weakly developed argic horizons may be present in some tenic B horizons. (See also B horizons and transitional horizons.).

In some soils underlain by a red-brown hardpan where there is no discernible A1 horizon and no underlying C horizon, it is difficult to identify a B horizon if there is little or no colour change or increase in texture or development of structure. Such layers of uniform soil materials without identifiable overlying or underlying horizons may be considered as a tenic B horizon if there is no evidence of alluvial stratification or aeolian cross-bedding within them.

**Tephric materials**

These consist dominantly of tephra - unconsolidated, non-weathered or only slightly altered primary pyroclastic products of explosive volcanic eruptions. They include ash, cinders, lapilli, scoria, pumice and pumice-like vesicular pyroclastics. Volcanic bombs may occur, and some exotic ejecta such as limestone fragments.

**Thin ironpan**

Commonly a thin (2–10mm) black to dark reddish pan cemented by iron, iron and manganese, or iron-organic matter complexes. Rarely 40 mm thick. It has a wavy or convolute form and usually occurs as a single pan. It is also known as a placic horizon (Soil Survey Staff 1994).

**Transitional horizons**

There are slight differences in the definitions of these horizons between the Soil Survey Manual (Soil Survey Division Staff 1993) and the Field Handbook. The definition used in this classification is that used in the Soil Survey Manual, viz:

Horizons dominated by properties of one master horizon but having subordinate properties of another e.g. BC. The first symbol indicates that the properties of the horizon so designated dominate the transitional horizon.

Horizons with two distinct parts that have recognisable properties of the two kinds of master horizons indicated by the capital letters e.g. C/B. The first symbol is that of the horizon with the greater volume. Most of the individual parts of one horizon component are surrounded by the other.

**Unconsolidated mineral materials**

This term is used to describe various unconsolidated materials below the solum, such as some C horizons, buried soils, sedimentary deposits of alluvial, colluvial or aeolian origin, and transported ferruginous nodules or concretions, such as occur in some ferric and bauxitic horizons.

**Vertic properties**

Soil material with a clayey field texture (i.e. light clay, medium clay, heavy clay) or 35% or more clay, that cracks strongly when dry and has slickensides and/or lenticular peds. See also Comment following the definition of Vertosols.

In several countries, physical measurements are being used in soil classification to help define classes of shrink-swell clay soils. In South Africa (Soil Classification Working Group 1991), the definition of a vertic A horizon (which is the definitive feature of soils equivalent
to Vertosols) includes either slickensides or a plasticity index greater than 32 (using the SA Standard Casagrande cup to determine liquid limit) or greater than 36 (using the British Standard cone to determine liquid limit). Cracking is regarded as an accessory property, as is linear shrinkage which is stated to be usually greater than 12%.

Soil Taxonomy relies solely on morphology for the definition of Vertisols (as does FAO-UNESCO 1990), but in the definition of vertic Subgroups in Soil Taxonomy (Soil Survey Staff 1999) a linear extensibility of 6 cm or more is offered as an alternative to the usual morphological requirements of cracks, and slickensides or wedge-shaped aggregates. However, the 6 cm minimum applies to the soil in the upper 100 cm of the profile, or the depth to a lithic or paralithic contract, whichever is shallower. This hardly seems appropriate to a common Australian situation where thick sandy A horizons overlie shrink-swell B horizons, particularly as in most engineering situations topsoils tend to be removed.

In Australia, COLE is seldom determined other than for research purposes and hence there is no appropriate data base of representative Australian clay soils. In contrast, standard engineering tests (Atterberg limits and linear shrinkage) are widely used by engineers and some soil conservation departments. Unfortunately, it is often not possible to relate the test values to specific kinds of soil, let alone the presence or absence of morphological features such as slickensides and lenticular peds. One relevant paper is that of Mills et al. (1980) who found in a study of 14 clay subsoils (three of which were Vertosols) in New South Wales that linear shrinkage was an appropriate method to predict shrink-swell activity but this was not related to morphology. Critical linear shrinkage limits of Mills et al. (1980) and for several other engineering authorities are given by Hicks (1991). Linear shrinkage values of 12-17% are rated as being marginal or moderate, with greater than 17% rated as a critical or high shrink-swell potential. However, Holland and Richards (1982) suggest that in arid and semi-arid climates, where pronounced short, wet and long, dry periods lead to major moisture changes, the linear shrinkage lower limits for moderate and high shrink-swell potential be 5% and 12% respectively.

McKenzie et al. (1994) have suggested that because the natural soil fabric is destroyed in the standard linear shrinkage test, the results can be difficult to relate to field behaviour. They have developed a rapid modified linear shrinkage test in which disruption to the natural soil fabric is reduced. This method was found to be a good predictor of COLE ($r^2 = 0.88$) with the slope of the regression line close to unity. The standard linear shrinkage was found to be a weaker predictor of COLE ($r^2 = 0.79$). In the 26 samples used, (that included two Vertosol profiles), the value for the standard linear shrinkage was always equal to or greater than the modified method.

There is obviously a need for further testing of all shrinkage methods on a wide range of Australian soils, and in particular to relate values to field morphology, as the latter may not always be a reliable guide to shrink-swell behaviour, particularly if salt and carbonate contents are high. McGarry (1995) has reviewed the various methods currently used to measure soil shrinkage.

For present classification purposes it is difficult to give firm guidelines. In the interim, a linear shrinkage of about 8% or greater by the modified version or about 12% or greater by the standard linear shrinkage (and/or a plasticity index $>32-36$) will help differentiate soils with vertic properties from others.

**Vesicular pores**

Soil pores characterised by the presence of vesicles or bubble-like structures, often associated with surface horizons and high salt concentrations in dry environments.

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5 The linear extensibility (LE) of a soil layer is the product of the thickness, in centimetres, multiplied by the COLE of the layer in question. The LE of a soil is the sum of these products for all soil horizons (Soil Survey Staff 1999).
**Water repellence**

Water repellence is a property of some soils, usually with sandy textures, that resist wetting by water. It is caused by a series of long chain polymethylene waxes, made up of acids, alcohols and esters, attached to sand grains. Degree of water repellence is assessed by determining the concentration of ethanol required to wet the sand in 10 seconds (King 1981). An abbreviated form of this method (NCST 2009) is recommended for routine field situations and is included as a Family criterion in susceptible Soil Orders.

Water repellence generally occurs in the surface layers of sandy soils and is typically associated with medium to coarse sands containing <5% clay. Fine to medium sands with 5–10% clay are less prone to water repellence.

**Weakly coherent B horizon**

These are Podosol B horizons in which the consistence strength ranges from loose to firm (i.e. force 0-3), although they may contain firm to very firm lumps (i.e. force 3-4) associated with accumulations of organic compounds, and occasionally there may be some hard sesquioxide nodules present. They do not contain pans of any kind.

**Wet panning**

A process where material is added to a pan and gently agitated in water. Materials with a low specific gravity are allowed to spill out of the pan, whereas materials with a higher specific gravity sink to the bottom of the sediment during agitation and remain within the pan for examination. For a detailed description of the method, readers are referred to British Geological Survey (2001).
Colour Classes

The class limits shown below (Fig. 3) have been chosen after examination of the Munsell colour charts and the scheme used for grouping in the Factual Key (Northcote 1979). A major aim was to achieve class limits as simple as possible and to standardise on these throughout the system. The proposed scheme has the virtue of simplicity although some may argue that 2.5YR 4/2 for example is not very grey, nor is 5YR 8/3 very red. These discrepancies can of course be removed, but at the cost of simplicity. Some of the more obvious ‘misfits’ are probably rare in soils. Colours should be matched to the chip closest in colour, or the nearest whole number in chroma where chips are not provided, for example chromas 5 and 7.

**Figure 3. Colour class limits. DO NOT use this in lieu of Munsell colour book in the field.**

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<td>The dominant colour (moist) for all hues has a value of 3 or less and a chroma of 2 or less.</td>
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<tr>
<td>Red</td>
<td>The dominant colour (moist) has a hue of 5YR or redder and a chroma of 3 or more.</td>
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<td>The dominant colour (moist) has a hue yellower than 5YR and a value of 5 or less and a chroma of 3 or more.</td>
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<td>Yellow</td>
<td>The dominant colour (moist) has a hue yellower than 5YR and a value of 6 or more and a chroma of 4 or more.</td>
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<td>Grey</td>
<td>The dominant colour (moist) for all hues has a value of 4 or more and chroma 2 or less; for hues yellower than 5YR values of 6 or more and chromas of 3 are allowed.</td>
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</tbody>
</table>

**Gley colours**

Greyish, greenish and bluish colours found in wet soils and defined by specific Munsell charts - usually 10Y–5GY and Gley charts 1 & 2.
References


REFERENCES


REFERENCES

CSIRO Australia, Soil Publication No. 27, CSIRO, Melbourne.


Appendix 1

Use of codes in recording classification of soil profiles

Confidence level of classification

In a number of instances it will not be possible to fully classify the soil because of a lack of laboratory data. It is desirable to indicate the level of confidence when any attempt at classification is made.

1. All necessary analytical and/or morphological data are available for the profile being classified.
2. Necessary analytical data for the profile are incomplete but are sufficient to classify the soil with a reasonable degree of confidence, e.g. free iron oxide data may be lacking but it is known that the soil is formed from basalt.
3. No necessary analytical data are available for the profile but confidence is fair, based on a knowledge of similar soils in similar environments, e.g. presence of columnar structure is normally a reliable indicator of sodic soils.
4. No necessary analytical data are available for the profile and the classifier has little knowledge or experience with this kind of soil, hence the classification is provisional.

Examples of a coded classification of a soil profile.
The codes presented in these examples are listed in the following Order: Confidence level; Order; Suborder: Great Group: Subgroup; Family criteria 1-5

This ordering is not prescriptive and the manner in which the classification is recorded on field data sheets is an operational matter. However, the national standard soil profile data base design, developed by the Australian Collaborative Land Evaluation Program (ACLEP), specifies that the coding system outlined in this classification is to be used for data exchange.

Example 1
1 CH AA AH AT A F L O T
This would decode as Bleached, Eutrophic, Red Chromosol; thin, slightly gravelly, loamy / clayey, very shallow. (Confidence level 1).

Example 2
If a level within the classification hierarchy is indeterminable from the available information this should be coded as [YY]: 4 KA AA YY BU
Ferric, ?, Red Kandosol (Confidence level 4). where YY is defined as: Class undetermined.

Example 3
If there is no available class this should be coded as [ZZ]: 1 RU AO ZZ AR
Basic, n/a, Arenic Rudosol (Confidence level 1 where ZZ is defined as: No available class.

Example 4
If only a subset of the Family criteria has been recorded then this should be coded as follows: 1 TE IN EA AI A - K K –
Acidic, Petroferric, Red Tenosol; thin, -, sandy / sandy, -, (Confidence level 1) where - is defined as: Not recorded

In this example it is important to note that Family criteria with a code of ‘K’ is valid for ‘A1 horizon texture’ and ‘B horizon maximum texture’. Recording of all the Family criteria is
essential. In order to avoid any future confusion or ambiguity, it is essential to record the Family criteria in the same Order as they are presented in the publication.
Appendix 2

List of codes and equivalent class names

Table A1 Order, Suborder, Great Group and Subgroup

* introduced in the Revised Edition
+ introduced in Second Edition
# introduced in Third Edition
^ no longer used

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</tbody>
</table>

(SO = Suborder, GG = Great Group, SG = Subgroup)
## Appendix 4

### Analytical requirements for the Australian Soil Classification

<table>
<thead>
<tr>
<th>Soil Type</th>
<th>Analytical Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>ARENOSOLS</td>
<td>May need particle size analysis to determine clay % and confirm loamy fine sand and light sandy loam textures.</td>
</tr>
<tr>
<td>CALCAROSOLS</td>
<td>Use of ESP at Subgroup level</td>
</tr>
<tr>
<td>CHROMOSOLS</td>
<td>ESP will probably be needed for the upper 0.2 m of the B2 horizon to define the Order, and cations at Great Group level for the major part of the B2 horizon unless the B or BC horizon is calcareous or contains a calcareous horizon; for Subgroups, possible need for organic carbon or LOI (loss on ignition) to identify a humose horizon; possible need for ESP in the lower part of the B horizon.</td>
</tr>
<tr>
<td>DERMOSOLS</td>
<td>As for Chromosols except for ESP in the upper 0.2 m of the B2 horizon.</td>
</tr>
<tr>
<td>FERROSOLS</td>
<td>Probable need for free Fe if soil is not definitely formed on basalt, otherwise as above although few soils are yet known with sodic Subgroups.</td>
</tr>
<tr>
<td>HYDROSOLS</td>
<td>For some Suborders it may be useful to have water table conductivity. Some Great Groups of some Suborders may require ESP of the upper 0.2 m of any clear or abrupt textural B horizon. At the Subgroup level organic carbon or LOI may be required to identify peaty or humose horizons, and cations may be required to identify base status, Ca/Mg ratio and ESP of the B2 horizon.</td>
</tr>
<tr>
<td>KANDOSOLS</td>
<td>As for Dermosols</td>
</tr>
<tr>
<td>KUROSOLS</td>
<td>At Great Group level ESP will probably be needed in the upper 0.2 m of the B2 horizon and cations in the major part of the B2 horizon. At the Subgroup level, as for Chromosols.</td>
</tr>
<tr>
<td>ORGANOSOLS</td>
<td>Organic carbon or LOI</td>
</tr>
<tr>
<td>PODOSOLS</td>
<td>Possible need for organic carbon or LOI to identify peaty or humose horizons.</td>
</tr>
<tr>
<td>RUDOSOLS</td>
<td>Possible need for conductivity at Suborder level.</td>
</tr>
<tr>
<td>SODOSOLS</td>
<td>ESP in the upper 0.2 m of the B2 horizon is needed to define the Order and the Great Groups. Cations required at the Subgroup level in the major part of the B2 horizon unless the B or BC horizon is calcareous or contains a calcareous horizon. Possible need for organic carbon or LOI to identify a humose horizon.</td>
</tr>
<tr>
<td>TENOSOLS</td>
<td>Organic carbon or LOI may be required at Suborder level to identify peaty or humose horizons.</td>
</tr>
<tr>
<td>VERTOSOLS</td>
<td>ESP required at the Subgroup level in 0.1 m and also cations at depths above and below 0.5 m. Water table conductivity</td>
</tr>
</tbody>
</table>
Particle size analysis will be required at the Family level to determine clay content.

Note that pH has not been listed above because it may be estimated in the field. Similarly, it is not essential to have particle size analysis to determine whether or not a soil has a clear or abrupt textural B horizon.
## Appendix 5

### Approximate correlations between the Australian and other soil classifications

<table>
<thead>
<tr>
<th>Order</th>
<th>Great Soil Group</th>
<th>Factual Key</th>
<th>Soil Taxonomy Order</th>
<th>World Reference Base</th>
</tr>
</thead>
<tbody>
<tr>
<td>ANTHROPOSOLS</td>
<td>No equivalent</td>
<td>No equivalent</td>
<td>No equivalent or HAHT soils(^1)</td>
<td>Anthrosols</td>
</tr>
<tr>
<td>ARENOSOLS</td>
<td>Siliceous sands, earthy sands, calcareous sands</td>
<td>Many Uc soils</td>
<td>Entisols</td>
<td>Arenosols, Regosols</td>
</tr>
<tr>
<td>CALCAROSOLS</td>
<td>Solonised brown soils, grey-brown and red calcareous soils</td>
<td>Gc1, Gc2, Um1, Um5 soils</td>
<td>Aridisols, Alfisols</td>
<td>Calcisols</td>
</tr>
<tr>
<td>CHROMOSOLS</td>
<td>Non-calcic brown soils, some red-brown earths and a range of podzolic soils</td>
<td>Many forms of duplex (D) soils</td>
<td>Alfisols, some Aridisols</td>
<td>Abruptic Luvisols/Lixisols</td>
</tr>
<tr>
<td>DERMOSOLS</td>
<td>Prairie soils, chocolate soils, some red and yellow podzolic soils</td>
<td>Wide range of Gn3 soils, some Um4</td>
<td>Mollisols, Alfisols, Ultisols</td>
<td>Wide range of Reference Soil Groups including Chernozems, Phaeozems, Luvisols and Lixisols</td>
</tr>
<tr>
<td>FERROSOLS</td>
<td>Krasnozems, euchrozems, chocolate soils</td>
<td>Gn3, Gn4, Uf5, Uf6 soils</td>
<td>Oxisols, Alfisols</td>
<td>Nitisols, Lixisols. some Ferralsols</td>
</tr>
<tr>
<td>HYDROSOLS</td>
<td>Humic gleys, gleyed podzolic soils, solonchaks and some alluvial soils</td>
<td>Wide range of classes, Dg and some Uf6 soils probably most common</td>
<td>Aquasols(^2), Ultisols, Inceptisols, salic Aridisols, Histosols</td>
<td>Gleysols, Stagnosols, Stagnic or Gleyic Vertisols/Fluvisols</td>
</tr>
<tr>
<td>KANDOSOLS</td>
<td>Red, yellow and grey earths, calcareous red earths</td>
<td>Gn2, Um5 soils</td>
<td>Alfisols, Ultisols, Aridisols</td>
<td>Ferralsols, Luvisols, Lixisols</td>
</tr>
<tr>
<td>KUROSOLS</td>
<td>Many podzolic soils and soloths</td>
<td>Many strongly acid duplex soils</td>
<td>Ultisols, Alfisols</td>
<td>Abruptic Acrisols/Lixisols/Alisols</td>
</tr>
<tr>
<td>ORGANOSOLS</td>
<td>Neutral to alkaline, and acid peats</td>
<td>Organic (O) soils</td>
<td>Histosols</td>
<td>Histosols</td>
</tr>
<tr>
<td>PODOSOLS</td>
<td>Podzols, humus podzols, peaty podzols</td>
<td>Many Uc2, some Uc3, Uc4 soils</td>
<td>Spodosols, some Entisols</td>
<td>Podzols</td>
</tr>
<tr>
<td>RUDOSOLS</td>
<td>Lithosols, alluvial soils, some solonchaks</td>
<td>Uc1, Um1, Uf1, soils</td>
<td>Entisols, salic Aridisols</td>
<td>Fluvisols, Leptosols, Arenosols</td>
</tr>
<tr>
<td>SODOSOLS</td>
<td>Solodized solonetz</td>
<td>Many</td>
<td>Alfisols,</td>
<td>Solonetz, Abruptic</td>
</tr>
</tbody>
</table>
and solodic soils, some soloths and red-brown earths, desert loams | duplex (D) soils | Aridisols | Luvisols, Planosols

**TENOSOLS**
- Lithosols, some siliceous and earthy sands, alpine humus soils and some alluvial soils
  - Many Uc and Um classes
  - Inceptisols, Aridisols, Entisols
  - Cambisols, Leptosols, Plinthosols

**VERTOSOLS**
- Black earths, grey, brown and red clays
  - Ug5 soils
  - Vertisols
  - Vertisols

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1 Human-Altered and Human-Transported soils

2 Proposed for the 13th Approximation

This table is intended only to give an idea of soils that approximately correspond to the orders of the new scheme. It is not meant to be used as an accurate translation between the various classification schemes. In many cases only major nearest equivalents can be given as differentiating criteria often differ between the four systems. No equivalent classes are available for Anthroposols, although some would fit into Entisols.
Appendix 6

History of the development of the Australian Soil Classification

Activities that led to the Australian Soil Classification (ASC) commenced in 1981, when the Soil and Land Resources Committee (SLRC, then a sub-committee of the Standing Committee on Soil Conservation-SCSC) recommended the formation of a working party to look into the need for and the options for improving soil classification in Australia. In 1982 a questionnaire on the subject was sent to all members of the Australian Soil Science Society, the results of which were published (Isbell 1984). The working party (Ray Isbell, Pat Walker, David Chittleborough, Robert van de Graaff, Ron McDonald) recommended to the SCSC (via the SLRC) in 1984 that a soil classification committee be established under the auspices of SLRC to formulate a proposal for the establishment of a new or revised Australian Soil Classification. The working party also listed various options for this task, and provided a number of guiding principles.

The soil classification committee was formally endorsed by the SCSC early in 1985, with the following membership: Ray Isbell (Convener), David Chittleborough (SA), Alex McBratney (QLD), Ron McDonald (QLD), Brian Murphy (NSW). Ian Sargeant (VIC) joined early in 1986.

The committee first met in August 1985 in Brisbane - Ken Day (NT) also attended. This meeting endorsed with some amendment the 'guiding principles' of the earlier working party, and examined the various options available for a new or revised classification, particularly in the light of the replies of the earlier questionnaire.

The various options considered were:

1. Revision of the existing Stace et al. (1968) great soil group scheme. This was not considered practical but the scheme
2. Revision of the existing Stace et al. (1968) great soil group scheme. This was not considered practical but the scheme could be partly used as a basis for the preferred option.
3. Revision of the Factual Key. This was not practical given the structure of the classification. Also, it cannot strictly be considered as a general purpose scheme given the limited nature of the attributes used. However, appropriate features of the system could be incorporated into any new classification scheme.
4. Adoption of an overseas scheme, for example Soil Taxonomy (Soil Survey Staff 1975) or FAO-Unesco (1990). The data base on which these schemes were constructed related mostly to northern hemisphere temperate zone soils, therefore, it could not be expected that these would be the most appropriate for Australian soils. Experience has shown this to be true.
5. Adaptation of an overseas scheme to Australian needs and conditions. This was thought to be quite impractical and would also lead to confusion.
6. Development of a computer-based numerical system. Although some experiments have been conducted, no such scheme has yet been developed on a national basis anywhere in the world. Although techniques were becoming available, the lack of standardised data is and will continue to be a problem for the foreseeable future.

During and following the 1985 committee meeting, attempts were made to establish likely diagnostic horizons, and existing classes of Australian soils - for example, Stace et al. (1968) great soil groups and some Factual Key classes - were grouped into provisional new classes at
various hierarchical levels. A meeting in July 1986 devoted particular attention to the question of creating classes using numerical methods. Subsequent exercises using the computer-based fuzzy set techniques developed by Alex McBratney were tried. An appropriate methodology does exist, but the present insurmountable problem was the lack of an adequate representative data set.

In March 1987, a preliminary version of the classification was sent to 25 pedologists around Australia for comment. The many useful replies were considered by the Committee at a meeting in Sydney in July 1987. Due to lack of any funding arrangements, no formal meetings of the Soil Classification Committee took place until it was reconstituted through the Working Group on Land Resource Assessment and the Australian Collaborative Land Evaluation Program in the early 1990s.

In late 1989, a ‘First Approximation’ of the scheme was issued as an unpublished working document (CSIRO Division of Soils Technical Memorandum 32/1989). This was widely distributed to some 200 people throughout Australia - many as a result of requests. The period from late 1989 to late 1991 was devoted to extensive testing of the scheme, both in the field and by checking relevant publications, and to a lesser extent by interrogating the CSIRO Division of Soils data base.

A 'Second Approximation' issued in January 1992 was a very much expanded version of the earlier one. Although the number of Orders remained the same, one was dropped (Melanosols) and one added (Dermosols). The main reason for the omission was that the diagnostic surface horizon of Melanosols is too easily lost by erosion or modified by human action - a problem similarly encountered in the Mollisols of Soil Taxonomy. The other major change was the narrower definition of Ferrosols as soils with high iron contents. The introduction of Dermosols catered for similar structured soils that lack high iron contents.

In August 1992, the Australian Soil Conservation Council formally endorsed the new classification and recommended its adoption by all States and Territories and its use in all future federally funded land resource inventory and research programs. During 1992-93, a National Landcare Program grant enabled extensive field travel around Australia, and provided for an assistant to carry out extensive testing of the classification via published data and unpublished material in data bases.

The 'Third Approximation' (Isbell 1993) followed extensive testing during 1992, both in the field and by checking relevant publications and, in particular, the comprehensive Queensland Department of Primary Industries soil profile data base. Over 300 copies of this version were distributed to individuals and organisations, as well as copies to the approximately 70 people actively engaged in soil survey activities in the various States at this time. During 1993 the increased testing activity (including field workshops) resulted in three sets of amendments being distributed. In 1994, testing continued via published soil profile descriptions and other data bases, and frequency distribution tables for all hierarchical levels of the classification were derived from the data base. These enabled an assessment of the relative importance of the various classes, in particular at the Subgroup level.

The Testing Procedure

The creation of a new classification scheme essentially involves the erection of a tentative framework and testing it, preferably in the field but also via profile descriptions. The basic test for any classification is that the variance within classes must be less than that between them. Perhaps the simplest test is to see if you end up with very different soils in the same pigeon hole, with only the keying properties in common. In all classification schemes it is hoped, sometimes assumed, that there is a degree of covariance between the keying properties and those you wish to predict. Unfortunately, experience has shown that the degree of covariance between some soil properties is either low or not well established. This particularly applies to prediction of various chemical and physical properties from conventional soil morphology.
The testing procedure was one of continual modification leading hopefully to improvement, and although the Australian soil population is probably finite, the law of diminishing returns also applied here. Over the period concerned Ray Isbell personally described and classified in the field in excess of 1000 profiles in all States. The use of these and soil profile descriptions in data bases and in publications dating back mostly to the early 1940s enabled the creation of a classification data base of 14 000 profiles, many of which had accompanying laboratory data. The data gave a good indication of the representativeness or otherwise of the data set used to test and modify the classification.

No data was recorded for Anthroposols.

There was an apparent bias towards Queensland, but this merely reflects the much greater availability of good quality soil profile data over many regions of this State. Considered on an area basis, the number of profiles classified per 1000 km² ranged from 17.5 for Australian Capital Territory to 0.6 for Western Australia, with Tasmania 7.2, Victoria 5.0, Queensland 3.8, New South Wales 2.8, South Australia 1.5 and Northern Territory 0.6. However, it was not so much a matter of how many, but how representative were the profiles classified.

At the time there were large areas of Australia for which little or no soil data are available. These include, in general terms, the Northern Territory south of Daly Waters, but excluding the area around Alice Springs. Similarly, data are also scarce in approximately the northern three-quarters of South Australia. In Western Australia there are large areas with little or no available data, essentially east of a very approximate line joining Esperance and Port Hedland, but excluding the Kimberley region, the Nullarbor Plain and the southern part of the Great Victoria Desert. All of these are arid, and thus the lack of data is not surprising. However, there are also unexpected areas where data is sparse in spite of relatively intensive land use, e.g. significant parts of the Murray-Darling Basin, although soil surveys are currently in progress.

The data also reflected to some extent the distribution of certain major Australian soils. Thus the Calcarosols are most prominent in South Australia and the Vertosols in Queensland and New South Wales. The percentages of soils with accompanying laboratory data obviously reflect the agricultural importance of some soils, but this was often confounded by different attitudes between States in relation to laboratory analyses.

In spite of some deficiencies shown up by this analysis, it was thought at the time that this sample of the Australian soil population was reasonably representative of Australian soils as a whole. Certainly it was much more so than the data available for earlier classification systems. Obviously more data would have been desirable for Anthroposols and Organosols, and to a lesser extent Podosols and Rudosols. Even so, it was thought that the available knowledge of these soils (with the exception of Anthroposols) was adequate for the purposes of classification. With regard to the large areas of arid Australia indicated above where knowledge is scanty, there was sufficient indication from adjoining regions that the major soils in these areas are likely to be dominated by Tenosols, Rudosols and Kandosols of a kind common elsewhere in the arid zone.

Since its publication in 1996, the Australian Soil Classification has been widely adopted and formally endorsed as the official national system. Responsibility for maintenance and updating now resides with the National Committee on Soil and Terrain (NCST). The NCST also oversaw the Australian Collaborative Evaluation Program (ACLEP). It published a supporting volume (Concepts and Rationale of the Australian Soil Classification (Isbell et al. 1997), a CD entitled The Australian Soil Classification - An Interactive Key (Jacquier et al. 2001) a revised edition of the classification in 2002 and a second edition in 2016.

Following recommendations by the Australian Soil Classification Working Group, in 2016 the NCST released a Second Edition to accommodate new knowledge and understanding of soils containing sulfidic materials. Included in these changes was the introduction of Subtidal and Subaqueous soils. Soils with abundant ironstone gravels were also accommodated by a Sesqui-Nodular Great Group in Tenosols.

This Third Edition introduces a new Soil Order, the Arenosols, which represents the deep
sands that were formerly classified as Tenosols, Rudosols and Calcarosols. These latter Soil Orders have extreme morphological diversity and have been subject to extensive investigation, particularly in South Australia, south-west Western Australia and the Northern Territory. The main changes to the Third Edition are described in the Preface.