WINE AND THE MISTS OF THE DISTANT PAST: GEOLOGICAL TIME EXPLAINED

Many wine producers and writers attach crucial importance to the age and type of bedrock and soil but often confuse them in fundamental ways. **Alex Maltman** dispels the mists in which the whole subject seems sometimes deliberately shrouded

"The area's best vineyards are on *Turonian* soils." "The wine's secret is the gray-blue *Devonian* slate." "Our Shiraz grows in soils *500 million years* old." "*Cretaceous* limestone is best for our vines." In these quotations, what do all the words that I have italicized have in common? Answer: They are all to do with geological time. In this magazine a Champagne advertisement recently appeared that, being suitably restrained and tasteful, used just a picture and a mere eight words—two of them were Kimmeridgien (sic) and Jurassic.

It seems that many in the wine world find these kinds of words important and enjoy using them. Perhaps part of the appeal is that they carry an air of mystery, since they are evoking far distant times. I do, however, sense that many writers are not entirely comfortable with them. They are, after all, technical scientific terms that are dealing with tricky concepts. And in any case, how on earth do geologists know these things? How do they know that one rock is older than another one that looks pretty much the same? What do these geological time names actually mean, and how are those inconceivably long ages determined? In this article, I attempt to shed some light, in order to provide a context for the wine enthusiast.

But first, I should state my own position. I cannot see—to put it very bluntly—what, apart from passing academic interest, all this has to do in practice with vines and wines. The words are referring to the geological age of the vineyard bedrock, and surely the vine doesn't care, so to speak, how long ago that happened to form. By definition the bedrock is pretty much intact, apart perhaps from some fissures that may conserve supplementary water into which deep roots tap: It is the overlying loose material, the soil, that is largely used for water and nutrition. And almost invariably, the age of the soil will be *unrelated and vastly younger than the bedrock*.

The age of the soil is certainly relevant, since it is continually changing on a human time-scale. To stretch a point, every time a grower walks his vineyard, every time a machine drives over it, some of the soil's properties will be at least fractionally affected; every rainstorm, every harvest will modify the chemistry. But it is not the age of the soil we are talking about here. Quotations like those above, even if they say "soils," are referring to bedrock, and how many hundreds of millions of years ago it formed would seem to be of no practical relevance.

Be that as it may, the fact is that these geological words and concepts are used very commonly, in all kinds of wine literature, and so I would like to help their being used correctly and with understanding. How geological time works is perhaps best understood by recalling how it was "discovered." So, in outline, this is the story.

The dawn of geology

Modern geology began two or three centuries ago, essentially when it dawned that questions about the physical world were better answered by going out and observing nature rather than poring over ancient scriptures. Very soon, once this particular penny had dropped, various "principles" were being enunciated. They were given noble titles, though they seem pretty much self-evident to us now. For example, the "principle of superposition" tells us that (just like with pouring sand into a bucket) in a pile of sediment layers, the lowest was deposited first—it is the oldest—and the layers get younger upward. The "principle of original horizontality" observes that all sediments are originally laid down in horizontal layers (even on a hillslope, because Earth's gravity works vertically downward), so that if we see inclined layers the tilting must have happened later. The "principle of cross-cutting relations" says that a particular geological feature that cuts across another one must be the younger of the two; the other one must have been there already in order to become cross-cut. With such armory, the early geologists were in a position to look at, say, some rocky cliff and work out a sequence in which things happened, even if it was in the distant past.

Less straightforward was linking this sequence with that seen at some other place—what geologists call *correlation*—but even the pioneers had ways. For example, if a particularly distinctive feature was involved, say an unusual volcanic ash deposit, it could act as a marker. The white, powdery, fossil-rich chalk seen in southern Britain—the foundation of numerous English vineyards—is a very characteristic deposit. The conditions on the sea floor thereabouts at the time of chalk formation were very special. The hardened and uplifted rock now makes the famous White Cliffs of Dover and the English coast around them, but there are very few places in more distant parts of the world where it occurs. It is distinctive.

Chalk does appear, however, on the other side of the English Channel in the cliffs around Boulogne, so it seems reasonable to correlate these strata, to infer that they were physically joined until the Channel was eroded down through them. In France, this same distinctive chalk formation stretches southeastward, all the way into the Champagne region and beyond. So, although the occurrences today are spread and not continuous, geologists correlate them. Also, the particular fossils the chalk contains are different from those in the strata below, which are different from those above. Elsewhere, this same order of fossils is found even where the middle formation is not chalk but some other sedimentary rock. The inference is that in such places the conditions on the sea floor were not suitable for chalk deposition, but the material is of the same geological age as the chalk.

Using these kinds of principles, the early workers were soon able to define past intervals of geological time, and they gave them names. The kind of scheme that resulted is the foundation of the geological timescale we use today (fig.1, *opposite*). Many of the names came from the places where good evidence was first recognized: Devonian from Devon, Permian from Perm, Jurassic from the Jura, and so on. Cambrian came from Roman attempts to render in Latin—Cambria—the local Celtic name for the land today called Wales: Cymru. The pioneers realized that these Cambrian rocks were very old, but also that there were even older ones, which were exceedingly difficult to disentangle. So they were simply shrugged off as "Pre-Cambrian" (note, for the moment, the hyphen).

This approach of inferring that one thing is older than another is called "relative dating." There are no numerical dates or times involved. It's like historians saying that the Renaissance came before the Baroque but without giving any years. This new demystifying of the Earth's history thrilled the public in Victorian times and elevated geology to a heroic science. In line with this, at the 1851 Great Exhibition in London, the grounds of the Crystal Palace incorporated a huge representation of the newly conceived geological timescale, complete with oversized models of fossils. In the hollow body of the iguanodon, a celebratory fine dinner was staged. ("Sherry, port, moselle and claret" were served.) The geologists of the time could be mightily proud of their achievement.

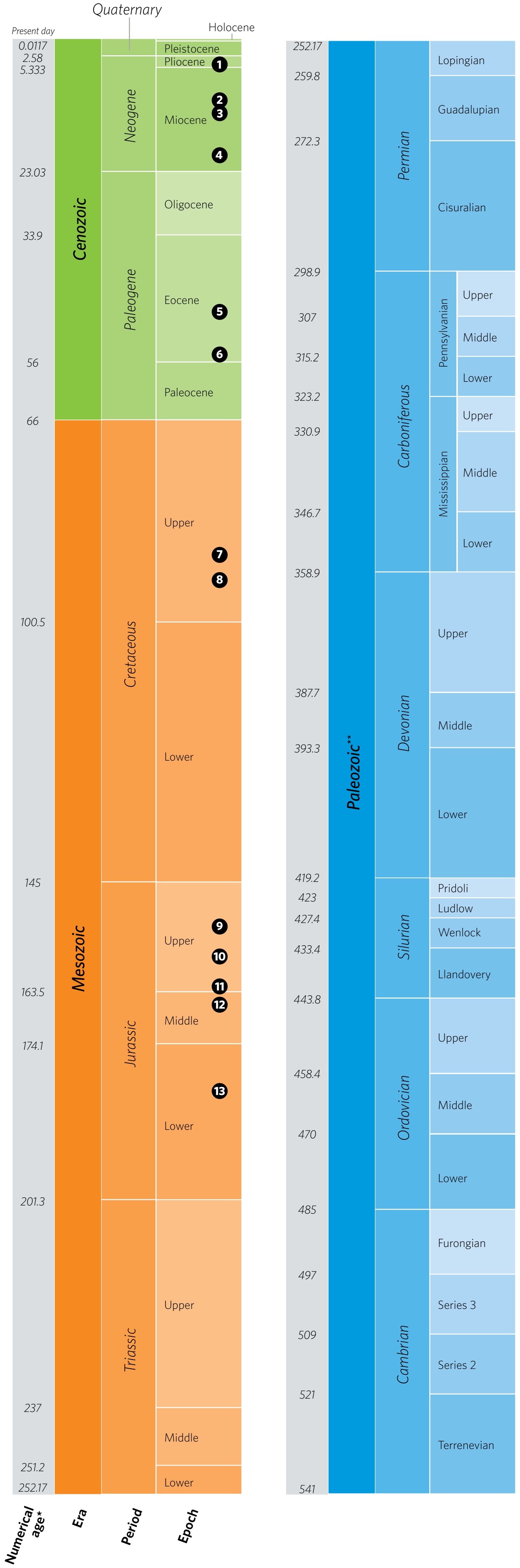
But there was a big problem. Something was glaringly missing. *How old* were these geological periods? *When* did they happen and *how long* did they last? No one knew, and there was no way of finding out. I imagine that those pioneering geologists would have given their eye-teeth for a way to put some numbers on their timescale.

The discovery of rock dating

Geologists call the business of giving a numerical age to a rock "dating" it—source of many an undergraduate quip about geologists loving their subject. The approach is properly called numerical dating. It's like art historians (continuing the analogy mentioned above) saying that the Renaissance started about 700 years ago and the Baroque period about 400 years ago. Ingenious ideas were proposed on how this could be achieved in geology, such as counting the growth rings on fossil corals, estimating the rate of supposed increasing salinity of the oceans or of Earth's inferred cooling from a primeval fiery state. Unfortunately, there was a suspicion, even at the time, that the bases of these procedures were mistaken, and we now know that to be the case.

Another seeming flaw with these methods was that they gave an age for the Earth in many *millions* of years. That struck

Figure 1

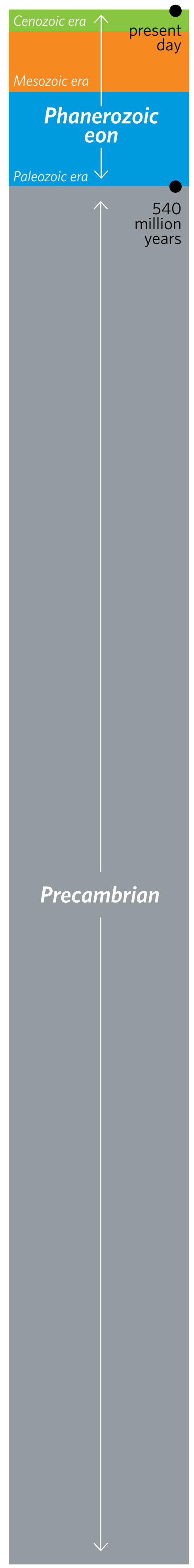


* Millions of years. ** Scale of the Paleozoic era is not drawn in relation to the scale of the Mesozoic / Cenozoic eras.
Source: www.stratigraphy.org/ICSchart/ChronostratChart2015-01.pdf, where the complete chart may be downloaded

KEY AGES MENTIONED IN THE TEXT
(time period)

1. Zanclean *(3.6–5.333)*
2. Tortonian *(7.246–11.63)*
3. Serravallian *(11.63–13.82)*
4. Burdigalian *(15.97–20.44)*
5. Lutetian *(41.2–47.8)*
6. Ypresian *(47.8–56)*
7. Coniacian *(86.3–89.8)*
8. Turonian *(89.9–93.9)*
9. Tithonian *(145–152.1)*
10. Kimmeridgian *(152.1–157.3)*
11. Oxfordian *(157.3–163.5)*
12. Callovian *(163.5–166.1)*
13. Toarcian *(174.1–182.7)*

Figure 2



Triassic rock formations. Close-up of a sandstone rock face showing the strata (layers). This rock face dates from the Triassic period (around 200 million to 250 million years ago) and is where unidentified dinosaur footprints have been found. Photographed overlooking the Severn Estuary, UK.

Photography by David Woodfall / Science Photo Library

The enormous numerical ages we now recognize are beyond our comprehension. But that, as I plead with my students, is no reason for us to be cavalier with the numbers. And I'm afraid that numerous writings, even responsible ones, have it all wrong

even some geologists as unthinkably long. In the centuries preceding all this, various clerics had attempted to work out the age of the Earth from translated scriptures, and though estimates varied, none of them exceeded 10,000 years. In the English-speaking world, a particularly influential "computation" (sic) based on interpreting a number of Christian and other texts pinpointed the origin of the Earth as a particular October day in 4004 BC. It became something of a dogma. But with the emergence of geology, it was soon realized that this gave nowhere near enough time to explain the observed features of the world. Few, however, conceived of many millions of years, let alone the vast periods known today.

Eventually, bit by bit, a method emerged for dating rocks that was sound and reliable. But it was very slow going. Radioactivity was discovered in the late 1800s, and it took the first decades of the 20th century to elucidate its nature. Strings of Nobel prizes ensued as it was demonstrated that certain natural elements were intrinsically unstable and through time gradually decayed—that is, threw off some of their constituent parts (radioactivity) to attain a more stable arrangement.

Understanding of the physics became ever more sophisticated, and it became clear that the rate of decay of any given radioactive element was fixed—not just roughly constant, but an unchanging fundamental property, no more variable than, say, the speed of light. Before long, there was analytical equipment that actually allowed the behavior of short-lived radioactive elements to be tested and measured, and it all agreed. No matter how extreme the conditions, the rate just could not be made to change.

And so it dawned that if we could analyze the proportions of decaying matter in rocks, then, knowing the rates, we could work out how long the process had been happening—that is, the age of the rock. In, for example, a rock solidifying from a hot, lava-like melt, the radioactive materials get locked into the crystal lattices of minerals, so today we can measure their proportions and derive when the process began. (These decaying elements and their products are different from those not involved with radioactivity, and so they are distinguishable. Technically speaking, they're different isotopes.)

Theory and laboratory observations agreed, the principle was simple and elegant; the main drawback at the time was the clumsiness of the analytical equipment. And the legacy problem persisted; when this method was tried, the rock ages came out in *hundreds of millions* of years. It was such a mental wrench from what had been believed before. But as the technology improved, as more laboratories around the world came up with the same ages, as the same rocks repeatedly gave the same result and relatively younger or older ones gave corresponding numerical ages, the strictures of earlier thinking just had to be discarded and the method accepted. And for geologists, this nicely gave plenty of time to incorporate all the natural processes they dealt with, even the excruciatingly slow ones. It all fitted together. So, by the mid-20th century a convincing geological timescale, complete with numbers, had been established.

Much of the work since then has been refinement and tackling those rocks that are hard to date, because they either have very little radioactive material or, for various reasons to do with their history, give values that are hard to interpret. Equipment has improved unimaginably such that all sorts of radioactive elements can now be analyzed, and if any further corroboration of the method were needed, there are now a dozen or so ways of dating rocks, based not on radioactivity but on quite different physical principles. Each of these is restricted to certain kinds of rocks or certain periods of geological time, so lacks the power and versatility of the radioactive method, but they all give results that agree.

Immense but manageable

The enormous numerical ages we now recognize are, of course, beyond our comprehension. But that, as I plead with my students, is no reason for us to be cavalier with the numbers. If we are to understand geological time we at least have to get the orders of magnitude right, the exact numbers of zeroes. And I'm afraid that numerous writings, even responsible ones, have it all wrong. I wonder to students if they would be so carefree with the zeroes if it were money—say, your first prize in the Euro-lottery or the hundred-billion-dollar Zimbabwean banknote in your hand as you attempted to buy something. In Croatia today, you can buy a bottle of wine for €5 or $7; in the 1990s you'd have to count up the zeroes on a banknote (and then realize it wasn't enough).

As technology improved, it became possible to date even the oldest rocks on Earth, and geologists started talking about *billions* (thousand millions) of years. It turns out that the Earth formed about 4.6 billion years ago. One thing this means is that the greater part of the planet's history is occupied by what is now called the Precambrian (note now the lack of a hyphen!). It occupies more or less the 4 billion years of Earth's age, which means the remaining fractional part—the 0.6 billion or 600 million years—covers pretty much all the geological time we talk about in vineyards (fig.2, *p.95*). There are vineyards on bedrock a billion years or more in age—such as at Stellenbosch in South Africa, in Western Australia, and a number of US states, including Virginia and the Texas Hill Country—but it so happens that most are on geologically young bedrock.

Not uncommonly, descriptions of the geology of a vineyard say that it formed in past millennia, which really means just thousands of years. Or it formed back in prehistory, which properly means the time of humans before written records began—that is, just a couple of hundred thousand years ago or so. In general, however, the geological age of vineyard bedrock is measured in *hundreds of millions* of years, or more. If our understanding of the geological ages of vineyard rocks and soils is to make any sense, we have to have the order of magnitude right.

The geological timescale

So, the coming together of the relative- and numerical-dating approaches has given us the geological timescale (fig.1, *p.95*). Its framework is by now very well established, and it provides a working calendar of the Earth's history. But there remain plenty of terminological problems in detail, and one difficulty that impinges on the wine world stems from the plethora of names that the geological pioneers established but that are no longer used in geology. The early names were often parochial, with no obvious correspondence to names elsewhere. Moreover (as though not to make things too easy!), the early geologists liked to modulate the name a little, such as with Toarcian, which comes from Thouars, in the Loire Valley, and Coniacian, derived from the city of Cognac. They also liked to show off their knowledge of classical times. Thus, the Zanclean stage is named after Zancla, the pre-Roman name for Messina on Sicily; Callovian is from the Latinized name for Kellaways Bridge, near Chippenham, in Wiltshire, England. I have seen all of these names in wine writings. How many modern wine drinkers know the Latin name for Bordeaux? It's Burdigalia and gives its name to the Burdigalian stage; the Lutetian comes from Lutetia, the Latin name for Paris.

But it is the parochiality of many of the names that is problematic in these days of global communications. And so for some decades now, a thoroughly international geological commission (www.stratigraphy.org) has existed, which has a formal and quasi-democratic system of agreeing which of the local names should be discarded and which adopted internationally, in the interests of regularizing and harmonizing usage across the world. The commission also attempts to identify and agree where in the world the rocks definitively representing each named interval exist. As it turns out, rarely do these most useful localities coincide with the places that spawned the name. Thus, for example, the Ypresian stage, which long ago took its name from Ypres (Ieper) in Belgium, is now defined in rocks near Luxor, Egypt; the name Turonian (which also finds itself as the name of a Vouvray wine) came from Tours, in the Loire Valley, France, but the agreed reference rocks today are near the town of Pueblo, in Colorado, USA.

By and large, the commission's recommendations have been smoothly absorbed into geology, but wholly understandably they have proved slow to trickle into the wine world. The upshot is that a number of terms commonly seen in wine writings have a meaning that now diverges from its correct usage in geology—or, indeed, have become technically obsolete. A few examples follow of these kinds of things. All the terms are seen in wine literature, and all clearly are serving a purpose there, but in different ways they are at variance with the modern usage in geology.

Many wine enthusiasts will think of Kimmeridgian as meaning the marls and limestones that underlie classic wine regions such as Chablis. But the name simply signifies that the rocks formed in Kimmeridgian times. It is wrong to use "Kimmeridgian" to mean a certain kind of rock

Helvetian, Tortonian, and Serravallian in Barolo

In the Barolo region of the Italian Piemonte, growers have long recognized that the wines produced from the west of the area tend to diverge in character from those produced in the east. The difference is often ascribed to the bedrock of the two areas, which varies somewhat in nature, and it is usually its differing geological ages that are highlighted. Thus, we read that the rocks of the western area are Tortonian, whereas those in the east are Helvetian. Without extra knowledge, these names simply indicate the time at which the rocks formed, nothing more, but my purpose here is to illustrate the localized name problem and how things evolve with improved geological knowledge.

Barolo has an intricate history of different local geological names being employed, and way back in 1865 the term Serravallian was proposed for the time at which the rocks in the east of the area formed. The name came from a municipality right there in the Piemonte region: Serravalle Scrivia. But it never caught on. Helvetian became preferred instead, even though that name obviously derived from relatively distant Switzerland. So, Helvetian became the established term, and geologists used it in Piemonte and elsewhere right up until 1957. Then they discovered that it was an inappropriate name, because the Helvetian rocks in Switzerland turned out to be equivalent in age to the already established Burdigalian stage! "Helvetian" had to be discarded. But the rocks in eastern Barolo weren't Burdigalian, so what to call them? The old name Serravallian was revived, and it is now the official geological term for this particular geological age.

Actually, the reference rocks for the Serravallian are now defined in southern Malta, but the point here is that, although the word Helvetian is much seen in Barolo wine literature today, for over half a century the term has been obsolete in geology. So, technically speaking, to be in line with geological usage, wine authors ought to be using the term Serravallian and not Helvetian.

Muschelkalk

This term is often used in the wine world for a period of geological time—and once it was. In geology today, however, it is a subtle blending of time, place, fossils, and rock type.

When relative time was being explored in the early days of geology, it was in Germany that a Triassic period was defined, named because there it contained three clear divisions. The middle one was called Muschelkalk. The other two names, Bunter and Keuper, have disappeared from the international timescale, though they do occasionally appear in vineyard writings. Muschelkalk is also officially obsolete in geology but is still used fondly in Germany and neighboring countries by wine writers, and it appears on several wine labels.

The various rock types that comprise Muschelkalk are very largely calcareous, and replete with distinctive fossilized sea shells, hence its German name for "shell limestone." The setting in and around Germany in which these creatures lived and the sediments were deposited was very localized, so it proved difficult to correlate them with rocks elsewhere. Consequently, although the name Triassic has been retained internationally, for many years the definitions of its subdivisions have been based on rocks from elsewhere in the world. Thus the term Muschelkalk is used today only in northern and central Europe, for the unusual calcareous rocks that formed there during Middle Triassic times. And for the vineyards in that region. For example, Muschelkalk underlies parts of southern Pfalz, Rheinhessen, and central Franken in Germany, and Neusiedlersee-Hügelland in Austria's Burgenland. A number of grand cru vineyards in Alsace broadcast the fact that they are sited on Muschelkalk. But it is geologically wrong to say that the rocks formed in Muschelkalk times, and away from this region the term is little known.

Urgonian

This word is another blurring of time, place, overall rock character, fossils, and especially the setting in which the rocks formed. It is not a rock type as such—it doesn't appear in rock classifications. Nor is it an interval of geological time—there is no Urgonian on the geological timescale.

Extensive, warm, shallow waters, centered on what is now southern Europe but long since vanished, are known in geology as the Urgonian Sea. The closest analogue today is the Bahamas area, though that is on a lesser scale. The local conditions at the bottom of the Urgonian Sea varied a lot, such that the sedimentary rocks that formed there vary from sandstones to siltstones, from marls to fairly pure limestones. In some places the conditions were inhospitable to life, whereas in others the rocks that formed contain spectacular fossils. Nowhere is the latter more so than around town of Orgon, just southwest of Avignon, toward the head of the Rhône delta. The Romans called this place Urgon, thus the origin of the term.

That the term doesn't specify a particular geological age is shown by Urgonian rocks in the Helvetian Alps being well over 130 million years old, in the Ardèche between 112 and 114 million years, at Cassis slightly more, at Tavel and Lirac, somewhat less—in other words, a span of around 30 million years, involving four geological ages.

One type of rock that formed is a particularly strong and massive limestone, in places tens of meters in thickness. Today it makes a striking presence in the landscape and is often called Urgonian limestone. In Spain, for example, it forms the strange tourist-attracting shapes of the Enchanted City near Cuenca. It forms the magnificent cliffs at Cassis and the towering escarpments above vineyards in the Alps and the Jura. The striking Rocher des Doms, in the historic heart of Avignon, with panoramic views over the surrounding vineyards (and with the celebrated, incomplete, bridge at its foot), consists of this richly fossiliferous white limestone, deposited in the Urgonian Sea.

Kimmeridgian

Here we have a time term that is official, but with a catch that in the wine world it often carries more of an emphasis on rock type! Many wine enthusiasts will think of Kimmeridgian as meaning the marls and limestones that underlie classic wine regions such as Chablis and parts of the Loire. But this is additional knowledge—it is not conveyed by the word Kimmeridgian itself. The name simply signifies that the rocks formed in Kimmeridgian times, between 152 million and 157 million years ago. (Curiously, a wine was described recently in this magazine as tasting *Kimmeridgian*.)

Above: Precambrian stromatolites (from 800 million years ago). Stromatolites are sedimentary structures formed by the trapping and binding of particles by communities of marine microorganisms. Photographed at Halali, Namibia.

Photography by Sinclair Stammers / Science Photo Library

In fact, the rocks at Chablis differ from those around, say, Sancerre, and farther afield they are different again. Much of North Sea oil originated in black, organic-rich shales of Kimmeridgian age. On mainland northern Scotland there are Kimmeridgian conglomerates and boulder beds; below ground in northern Holland and in the northernmost North Sea, up towards Svalbard, the Kimmeridgian rocks are volcanic in nature. In the Levant, and in northern California and Oregon, some of the Kimmeridgian rocks are metamorphic. Thus it is wrong to use "Kimmeridgian" to mean a certain kind of rock. Unless some prior knowledge of an area is assumed, declaring that its vineyards are on Kimmeridgian bedrock is conveying nothing more than the geological epoch in which the rocks formed.

The term also provides an illustration of the practical difficulties facing the international commission in its efforts to rationalize things. Kimmeridgian rocks were originally defined at a now-classic geological locality (Ringstead Bay) near the village of Kimmeridge on the famous, fossil-rich "Jurassic Coast" of southern England. For various geological reasons, however, the commission has felt unable to make this historic location the global reference site. It has similarly had to dismiss all the obvious alternatives, which include the rocks in the European wine-growing regions. The problems and the rigor of the process are illustrated by the fact that the preferred location for defining the Kimmeridgian—at Flodigarry, on the Isle of Skye, Scotland, where the outcrops appear to fulfill all the necessary criteria—has been accepted as the best candidate by the commission for over a decade but is still unratified.

And then there's the matter of having to jettison some time-honored and much-loved names, which can touch on nationalistic sensitivities. Take, for example, the famous debate in the Chablis area on the extension of *appellation contrôlée* limits above Kimmeridgian rocks to include the so-called Portlandian. A glance at figure 1 (*p.95*) will show that actually the word Portlandian has been officially discarded in favor of Tithonian (a name derived from classical Greek mythology). English geologists were much dismayed at this decision, at having to forfeit their beloved name, derived from rocks in Portland, southern England, not least because the limestone at

Above: Seascape with Kimmeridgian rock ledges extending out into the sea.

Materials such as loess and alluvium—and these account for many of the world's vine-growing regions—have no connection with the bedrock on which they happen to rest. The age of the soil itself is quite independent of what geological age the parent bedrock happens to be

Portland is one of the nation's great building stones. Some of England's most celebrated monuments are constructed from it, including the poignant white headstones of the Commonwealth war graves and 135 buildings in London alone, including St Paul's Cathedral, Buckingham Palace, the British Museum, and the National Gallery.

But in some quarters, such loss of local names has met with chauvinistic outrage. One book on the wines of Chablis fulminates against the expulsion of a number of local French names for time intervals in the Jurassic period, proclaiming (in translation from the French original) that it came about because this "geological age [...] was completely monopolized by English men of science." The author goes on to assert this is "why it breaks down into headings that sound like donnish schools of thought." (He is referring to the Kimmeridgian, Oxfordian, and Callovian ages.) "Alas! Another Trafalgar." The beloved French names "went down with all hands in a sea of scientific disdain" and now remain merely "as nostalgic references to the defenders of authentic French culture."

That writer particularly blames a conference in 1962 in Luxembourg. Although it was attended by "the most eminent geologists from all over the world," at the meeting "one of the bright sparks present (an Anglo-Saxon) proposed to strike off the blackboard with a single stroke...the old chronology, and 'Kimmeridgian' was produced like a rabbit from a hat to fill the void." Impassioned indeed. The author does not mention that the term Jurassic was introduced by Alexandre Brogniart and that the term Kimmeridgian (and, for that matter, Oxfordian, Callovian, and Portlandian) was coined by Alcide d'Orbigny, both of whom were French.

Primary rock

We have just seen a number of time terms that are still used in wine writings despite being outdated in geology, but surely the record for this must go to the term "Primary rock." Vineyard descriptions from Austria, and especially those from the Wachau and Kremstal areas of the Danube, enthusiastically mention the word Urgestein, usually translated as "Primary rock," or occasionally as "Primitive rock," and that it dates from the Earth's "Primary era." In geology, however, these terms—both in German and in English—and the concepts they imply have been obsolete for around a couple of centuries. Austrian geologists have long been trying to discourage use of the word; geologists elsewhere would just be baffled by it.

The geological materials in those Danube vineyards consist principally of relatively recent loess and alluvium, which contrast with a range of older, very much harder rocks that includes amphibolite, slate, basalt, granite, gneiss, and schist. These comprise the Primary rock. So, with prior knowledge the term can provide a convenient shorthand summary label for that wide range of rock types. The problem is with the word "primary." It carries an implication of great antiquity, of something special, elemental, primeval, and some go on to believe that this brings something special to the wines. (Actually, with ages less than 500 million years old, little more than a tenth of the Earth's history, these rocks are, geologically speaking, not particularly old.)

In the dawning days of modern geology, there was a theory that the primordial Earth was entirely covered by a lifeless ocean, from which the metamorphic and igneous rocks were chemically precipitated. These were the Primary rocks, defining the Primary era of the planet's history. Then, after life had appeared in the ocean, sedimentary rocks formed and contained fossils: these were Secondary rocks, from the Secondary era. (Tertiary and Quaternary divisions were added later.) This thinking was widely admired and influential at the time, not only in its Saxon heartland but by some in Britain and other parts of Europe, too—but only briefly. For in addition to the physical snags of such implausible volumes of ocean water, incompatible geological observations rapidly accumulated. Igneous rocks were demonstrated to have been molten once and not precipitated, metamorphic rocks to be changed variants of rocks that went before, and, crucially, instances of both were reported that were demonstrably much younger than fossiliferous rocks. (That's why today, "igneous" and "metamorphic" have no age connotations.) Thus, the notions of a primeval ocean, a Primary era, and Primary rock rapidly disappeared from geology.

There are terms that are used in geology for softer materials overlying markedly stronger rocks: *cover* and *basement*. These words have no time implication. In the viticultural context, the sedimentary rocks that form South Africa's Table Mountain and the striking mountains around Stellenbosch and Franschhoek, are cover rocks to the metamorphic rocks and granites of the underlying basement. The Vosges Mountains of northern France largely comprise a basement of granite and gneiss, which on its eastern flanks underlies vineyards such as the famous Schlossberg, near Kayserberg, east of Colmar. Most of the Alsace vineyards, however, are located on sedimentary cover rocks.

Vineyards in the Côtes du Forez area of the southern Loire down into Auvergne are sited partly on geologically young volcanic rocks, which form a cover to the basement of granites and metamorphic rocks. In fact, in a highly simplistic view of France as a whole, the Massif Central and the Massif Armoricain (Brittany and western Normandy) are regional-scale patches of basement exposed within the cover of young sedimentary strata that veneer much of France, such as in the Paris and Aquitaine basins and the Rhône Valley. In other words, the concept of cover and basement rock is normal in modern geology; the notion of Primary rock has long since vanished.

Age of bedrock versus the age of soils

There seems to be an unwritten understanding that the adjectives in terms like "granite soils" or "limestone soils" don't literally describe the loose material of a vineyard but refer to the intact parent rock from which the soil was derived. And they do convey some general information on the likely nature of the soils. But where time adjectives are involved, things can get confused. For example, descriptions of vineyards located on Precambrian bedrock enthuse about how primeval the soils are; others tell of the importance for the vines in the Middle Mosel, Germany, of the Devonian soils; and in the Côtes de Provence, France, of the Permian soils. These soils, however, as distinct from the bedrock, are not of these ages; it's all a bit misleading.

Much-traveled materials such as loess and alluvium—and these account for many of the world's vine-growing regions—have no connection with the bedrock on which they happen to rest. And even in areas where the soil particles have barely moved, the age of the soil itself is quite independent of what geological age the parent bedrock happens to be.

For example, promotional literature on the Heathcote wine region in Victoria, Australia, is fond of enthusing about the vast antiquity of its "Cambrian-age soils," some even asserting them to be the oldest in the world. (In fact, most of the Heathcote bedrock is geologically younger than Cambrian, apart from two narrow strips, and even these are considerably younger than, say, the 1,500-million-year-old bedrock of parts of the Margaret River area.) But the point here is that the Heathcote soils are not of Cambrian age and are probably a few millions of years old at the most. And most soils are geologically very much younger than this. The Gimblett Gravels of Hawkes Bay, New Zealand, were forming until little more than a century ago!

The rate at which soils form from bedrock depends greatly on climate and a host of other things, so the numbers vary greatly. Some workers estimate that it takes around 100 years to generate 1–2 inches (2–5cm) of soil from volcanic ash in the warm, humid tropics, and 5,000 years to produce 0.4 inch (1cm) of soil from hard rocks in cool temperate climates. One often quoted global average value is 178 years to develop 0.4in of soil. Of course, whichever number we take, to us these are slow processes. But even so, they mean that soil ages are typically measured in thousands or perhaps a few millions of years, rather than the hundred-million-year ages of much vineyard bedrock.

Moreover, as the soil develops it undergoes erosion in one way and another. For example, whatever soils existed before the Ice Age in places like northern Europe, Tasmania, and New Zealand were stripped away by the ice sheets of those times, so the soils there today are no more than 12,000 years or so in age, at the very most.

The actual age of a soil is difficult to establish, not least because of its ongoing evolution (and the radioactive method won't work here), but we can talk very generally about young, mature, and old soils, or perhaps about the stage of compaction or nutrient leaching. Such aspects of soils are very relevant to viticulture. In other words, the age and properties of the soil are far more meaningful in vineyard descriptions than proclaiming the distant and unrelated geological age of the underlying bedrock—even if we understand how geological time works. ■