THE SOURCE

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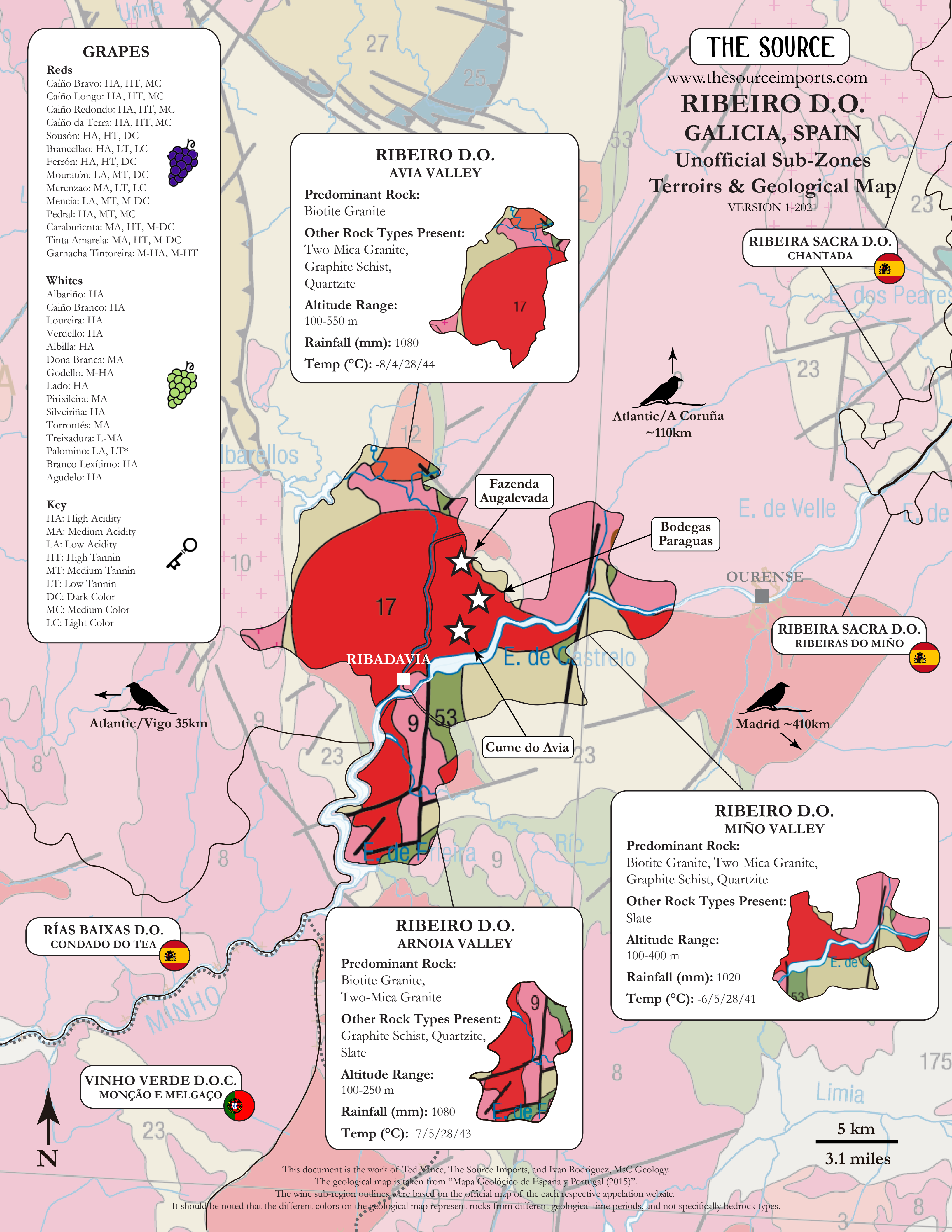
RIBEIRO D.O.
GALICIA, SPAIN
Unofficial Sub-Zones
Terroirs & Geological Map

VERSION 1-2021



GRAPES

Reds

- Caíño Bravo: HA, HT, MC
- Caíño Longo: HA, HT, MC
- Caíño Redondo: HA, HT, MC
- Caíño da Terra: HA, HT, MC
- Sousón: HA, HT, DC
- Brancellao: HA, LT, LC
- Ferrón: HA, HT, DC
- Mouratón: LA, MT, DC
- Merenzao: MA, LT, LC
- Mencía: LA, MT, M-DC
- Pedral: HA, MT, MC
- Carabuñenta: MA, HT, M-DC
- Tinta Amarela: MA, HT, M-DC
- Garnacha Tintoreira: M-HA, M-HT

Whites

- Albariño: HA
- Caíño Branco: HA
- Loureira: HA
- Verdello: HA
- Albilla: HA
- Dona Branca: MA
- Godello: M-HA
- Lado: HA
- Pirixileira: MA
- Silveiriña: HA
- Torrontés: MA
- Treixadura: L-MA
- Palomino: LA, LT*
- Branco Lexítimo: HA
- Agudelo: HA

Key

- HA: High Acidity
- MA: Medium Acidity
- LA: Low Acidity
- HT: High Tannin
- MT: Medium Tannin
- LT: Low Tannin
- DC: Dark Color
- MC: Medium Color
- LC: Light Color

RIBEIRO D.O.
AVIA VALLEY

Predominant Rock:
Biotite Granite

Other Rock Types Present:
Two-Mica Granite,
Graphite Schist,
Quartzite

Altitude Range:
100-550 m

Rainfall (mm): 1080

Temp (°C): -8/4/28/44

RIBEIRO D.O.
MIÑO VALLEY

Predominant Rock:
Biotite Granite, Two-Mica Granite,
Graphite Schist, Quartzite

Other Rock Types Present:
Slate

Altitude Range:
100-400 m

Rainfall (mm): 1020

Temp (°C): -6/5/28/41

RIBEIRO D.O.
ARNOIA VALLEY

Predominant Rock:
Biotite Granite,
Two-Mica Granite

Other Rock Types Present:
Graphite Schist, Quartzite,
Slate

Altitude Range:
100-250 m

Rainfall (mm): 1080

Temp (°C): -7/5/28/43

This document is the work of Ted Vance, The Source Imports, and Ivan Rodriguez, MsC Geology.
The geological map is taken from “Mapa Geológico de España y Portugal (2015)”.
The wine sub-region outlines were based on the official map of the each respective appelation website.
It should be noted that the different colors on the geological map represent rocks from different geological time periods, and not specifically bedrock types.

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GEOLOGICAL KEY

VERSION 2021-1

IBERIAN CONTINENTAL BASINS

0 to 2.5 Mya
- **175** Gravel, Sand, Clay, Shale (S)
- **174** Conglomerates, Sandstones, Gravel, Sand, Silt, Clay (S)
- **173** Conglomerates, Gravels, Sand, Shales, Sandstones (S) Limestones, Marls (C)
- **171** Conglomerates, generally quartzitic (“Rañas”) (S)

7 to 20 Mya
- **166** Conglomerates, Sandstones, Clays (S) Limestones, Marls (C)
- **165** Conglomerates, Sandstones, Shales (S) Limestones, Marls (C)
- **164** Conglomerates, Sandstones, Shales (S) Limestones, Marls (C)

28 to 56 Mya
- **162** Conglomerates, Breccias, Sandstones, Shales (S) Limestones (C)
- **161** Conglomerates, Sandstones, Shales (S) Marls (C)

IBERIAN VARISCAN MASSIF

250 to 390 Mya
- **87** Dacite, Rhyolite (F) Andesite (I) Basalt (M)
- **86** Sandstone, Shale, Conglomerate (S) Limestone (C)
- **85** Sandstone, Conglomerate (S) Slate (L) Coal (O)
- **83** Sandstone, Conglomerate, Shale (S) Coal (O)
- **76** Slate (L) Sandstone (S) Limestone (C)
- **70** Quartzite (N) Slate (L)

390 to 440 Mya
- **65** Black Schist (M) Radiolarite (S) Quartzite (N) Limestone (C)
- **64** Slate (L) Greywacke (S) Limestone (C)
- **63** Black Slate (L) Radiolarite (S) Quartzite (N) Limestone (C)

440 to 500 Mya
- **60** Slate (L) Sandstone (S) Quartzite (N)
- **59** Slate (L) Sandstone (S)
- **58** Slate (L) Sandstone (S) Quartzite (N) Limestone (C)
- **57** Black Slate (L)
- **56** Quartzite (N)
- **55** Schist (M) Slate (L) Quartzite (N) Conglomerate (S)
- **54** Glandular Gneiss (H)
- **53** Quartzite (N) Slate (L)

500 to 1000 Mya
- **47** Sandstone (S) Slate (L) Limestone (C)
- **45** Schist (M) Greywacke (S) Carbonated rocks (C)
- **44** Schist (M) Greywacke, Conglomerate (S) Quartzite (N)
- **43** Schist (M) Greywacke (S)

IBERIAN MASSIF ALLOCHTHON UNITS

490 to 1000 Mya
- **37** Para-Gneiss, Eclogite (H)
- **36** Slate (L) Schist (M) Para-Gneiss (H)
- **35** Ortho-Gneiss (H)
- **34** Meta-Gabbro, Amphibolite, Eclogite (H) Ultramafic Rocks (M) (M)
- **33** Ultramafic Rocks (M) (M)

390 to 490 Mya
- **32** Meta-Gabbro, Amphibolite (H) Meta-sediments (L) (M) Ultramafic Rocks (M) (M)
- **31** Ultramafic Rocks (M) (M)

410 to 490 Mya
- **29** Schist (M)
- **30** Greywacke (S) Slate (L)
- **28** Slate (L) Quartzite (N)
- **27** Schist (M) Greywacke (S) Para-Gneiss (H)
- **26** Ortho-Gneiss, Eclogite (H)
- **25** Amphibolite (H)
- **24** Slate (L) Greywacke (S) Quartzite, Marble (N)
- **23** Graphite Schist (M) Radiolarite, Greywacke (S) Quartzite (N)

540 to 1000 Mya
- **22** Mica-Schist (M) Greywacke (S) Quartzite (N) Amphibolite (M) (H)
- **21** Gneiss with garnet, Ortho-Gneiss, Migmatite (H)

VARISCAN IGNEOUS ROCKS

300 to 440 Mya
- **17** Biotitic Granitoids (F) (I)
- **16** Two Mica Granites (F)
- **15** Biotitic Granites with Cordierite (F)
- **13** Biotitic Granitoids (F) (I)
- **12** Two Mica Granites (F)
- **10** Biotitic Granitoids (F) (I) related Mafic Rocks (M) (M)
- **9** Two Mica Granite and Leucogranite (F)
- **8** Non-Homogeneus Granitoids (F) (I) Migmatitic Complexes (H)

440 to 540 Mya
- **3** Alkali-Calcic and Peraluminous Granitoids (F) (I) Glandular Ortho-Gneiss (H)

Igneous Intrusive	(F) Felsic	(I) Intermediate	(M) Mafic
Igneous Extrusive	(F) Felsic	(I) Intermediate	(M) Mafic
Sedimentary	(C) Calcareous	(S) Siliciclastic	(O) Organic
Metamorphic	(L) Low-grade	(M) Medium-grade	(H) High-grade
	(N) Non-foliated (any metamorphism grade)		

Mya: Million years ago.
Massif: Compact group of mountains connected forming an independent portion of land.
Continental Basin: Topographically low inland area where sediments can accumulate.
Allochthon Unit: A large block of rock moved tectonically from where it was formed.
Variscan: related to the Variscan orogeny. An ancient chain of mountains which was the result of the formation of Pangea.
Not present in this area of the Iberian Peninsula:
1, 2, 4-7, 11, 14, 18-20, 38-42, 46, 48-52, 61-62, 65-70 71-75, 77-82, 84, 88-160, 163, 167-170, 172

This document is the work of Ted Vance, The Source Imports, and Ivan Rodriguez, MsC Geology. The geological color key is based on the “Mapa Geológico de España y Portugal” (Rodríguez-Fernández, L.R., López-Olmedo, F., Oliveira, J.T., Medialdea, T., Terrinha, P., Matas, J., Martín-Serrano, A., Martín-Parra, L.M., Rubio-Pascual, F.J., Marín, C., Montes, M., & Nozal, F. (2015). *Mapa Geológico de España y Portugal a Escala 1: 1.000.000*. IGME (Spain) - INETI (Portugal). Madrid-Lisbon). This geological color key is a large scale geology map so other rock types may be present.

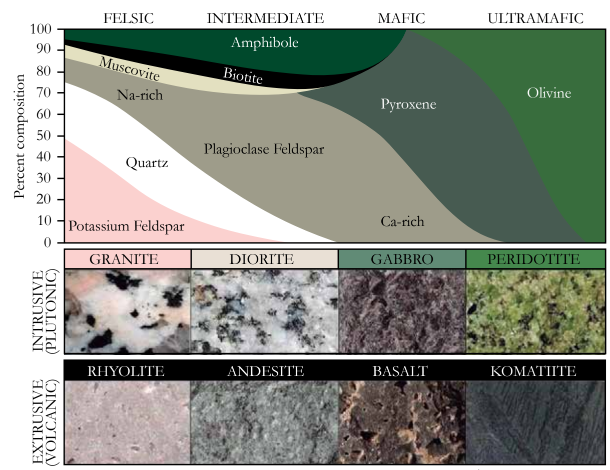
THE SOURCE

TERROIR MAP SUPPORT MATERIAL

This series of maps is intended to provide an understandable yet concise collection of data that provides useful context for the world's curious wine tasters. While science has already produced a great deal of research on the nature of wine, there is still so much more work to be done. Unlike many other terroir imprints, wine's relationship to rock and its mineral composition remains scientifically ambiguous, despite some observable patterns by people who have committed their lives to the subject. Within the science community there is a great deal of skepticism about this relationship, however history demonstrates that an open embrace of possibilities allows science to reach beyond its current limits. The technical elements of this work has been reviewed by researchers from the Department of Marine Geoscience and Planning Territory of the University of Vigo, Spain.

IGNEOUS ROCK

- Rock formed from cooling of magma.
- Intrusive/Plutonic: cooled slowly below the surface.
- Extrusive/Volcanic: cooled quickly above the surface.
- The Mineral crystal size of igneous rocks depends on the rate the magma cools. Slow cooling results in larger crystals than those that cool faster. Crystal size affects the soil grain size and has implications with soil water retention, which in turn influences a resulting wine's characteristics.
- Felsic, Intermediate and Mafic (also, Ultramafic) charts igneous rock mineral composition (see diagram 1).
- Intrusive and extrusive rocks from the same magma chamber share the same mineral makeup.
- Igneous rock pH levels are related to the composition classification. Felsic are more acidic, while the pH increases as we move to Mafic and Ultramafic.



Modified from K. Panchuk (1018) CC BY-NC-SA 4.0 and S. Earle (2015) CC BY 4.0. Photos by R. Weller/Cochise College and K. Panchuk

METAMORPHIC ROCK

- Rock altered (metamorphosed) from a pre-existent rock (protolith) by extreme conditions of pressure and/or temperature.
- Depending on how much these conditions affected the rock, they could be classified as low, medium or high-grade metamorphic rock.
- The main divisions of metamorphic rock are based on appearance and classified as either foliated or non-foliated and how pressure/temperature affected the preexisting rock.
- Each classification and location of metamorphic rock has a unique mineral composition, which leads to variance in modes of decomposition.
- Metamorphic rock pH levels mainly depends on the acidic/alkaline nature of the protolith.

ROCK NAME		TEXTURE	GRAIN SIZE	PARENT ROCK (PROTOLITH)
SLATE	INCREASING METAMORPHISM	FOLIATED	FINE	SHALE, MUSTONE OR SILTSTONE
SCHIST			MEDIUM TO COARSE	SLATE OR IGNEOUS ROCK
GNEISS			MEDIUM TO COARSE	SCHIST OR IGNEOUS ROCK
MARBLE		NON-FOLIATED	MEDIUM TO COARSE	CALCAREOUS ROCK
QUARTZITE			MEDIUM TO COARSE	QUARTZ SANDSTONE
ANTHRACITE			FINE	COAL

Modified from 2006 Pearson Prentice Hall, Inc.

SEDIMENTARY ROCK

- Rock formed from the accumulation of sediments, compaction and cementation (lithification).
- Three main types:
  - Siliciclastic: fragments of igneous and metamorphic rocks, mainly silicates.
  - Calcareous: mainly fragments of carbonate-rich organisms.
  - Organic-rich: containing significant amounts of organic carbon of biological origin.
- In general, pH levels in siliciclastic are acidic while calcareous are alkaline.

SILICICLASTIC			CHEMICAL	
GRAIN SIZE	SEDIMENT	ROCK	COMPOSITION	ROCK
COARSE (>2 MM)	ROUNDED GRAVEL	CONGLOMERATE	CALCITE ($CaCO_3$)	LIMESTONE
	ANGULAR GRAVEL	BRECCIA	QUARTZ (SiO_2)	CHERT / FLINT
MEDIUM (2 TO 0.062 MM)	SAND	SANDSTONE	GYPSUM ($CaSO_4 \cdot 2H_2O$)	GYPSUM
FINE (0.062 TO 0.004 MM)	SILT	SILTSTONE	HALITE (NaCl)	HALITE
VERY FINE (<0.004 MM)	CLAY	SHALE	PLANT FRAGMENTS (C+others)	COAL

WEATHERING + TOPSOIL COMPOSITION

- A vineyard's soil depth, grain and mineralogy influence a resulting wine's organoleptic characteristics.
- Erosion depends on mineral composition and degree of exposure within the environment.
- Rocks erode either by physical weathering (fragmentation) and/or chemical weathering (mineral dissolution).
- Physical weathering produces coarser soils. Chemical weathering produces finer soils.
- Inorganic components of soil are bedrock-derived and/or unconsolidated (transported) material.
- Soil tends to be composed of a mix of grains, which are broadly classified (small to large) as clay, silt, sand, or gravel.

CLAY

- Clay has more significant implications compared to other soil grains due to its increased water retention capacity and nutrient/mineral supply—a consequence of its smaller size and more complex composition.
- Clay has a higher CEC (Cation Exchange Capacity) than other soil grains, and each clay type has a different CEC and water retentive capacity. CEC level is directly related to fertility: e.g., low CEC implies low fertility. (Cation: An atom with positive electrical charge which allows them to be highly reactive with other atoms.)
- Four *main* clay mineral types:
  - Kaolinite has the simplest chemical composition, largest soil grain, relatively low CEC, and low water retention; it is referred to as a *non-swelling clay*. It's commonly a byproduct of weathered feldspar and muscovite from felsic rocks (rhyolite and granite), and allophane from recent volcanic rocks (tephra).
  - Illite is a potassium aluminum-rich clay with intermediate CEC and intermediate water retention. It is commonly a byproduct of weathered felsic igneous or high-grade metamorphic rocks.
  - Vermiculite is an iron and magnesium rich clay, with high CEC and intermediate water retention. It is commonly a byproduct of weathered biotite, chlorite and amphiboles (usually from volcanic rock).
  - Smectite is fine-grained with high CEC and high water retention. It is commonly a product of weathered basalts and other volcanic rocks. In sediments, these clay minerals have various origins and are most often reworked from soils where clay formed under warm, humid climates. It also forms in marine environments at the expense of volcanic glass or formed after slow deposition of sediments.

TEMPERATURE AND PRECIPITATION

- The Köppen climate classification (categorized as Oceanic, Continental, Mediterranean, etc.) is useful on a global scale, but concerning wine regions it can be vague and confusing (e.g. Galicia and all of Portugal are classified as Mediterranean). We have opted instead to use regional temperature and precipitation data.
- While generalities with precipitation and temperature are useful, geographical characteristics like altitude, slope, exposure, wind currents, and proximity to hills, mountains, water (rivers, oceans, seas, lakes) influence temperature, precipitation and humidity are specific to each terroir.
- Temperatures are arranged as lowest/average low/average high/highest (e.g. -4/0/28/33). These numbers better illustrate a region's climate than broad categorizations. It may also help with general concepts. Examples:
  - -7/1/30/43 from Portugal's Planalto Mirandês (PM) compared to -3, 7, 25, 38 from Spain's Val do Salnés (VdS) clearly demonstrates that winter lows and summer highs in PM are more extreme than the VdS which is more moderate on both ends.
  - PM vineyards may be affected by frost because temperatures below zero may happen after vegetative cycles begin, while in VdS vineyards are not affected (yet) because the temperatures may only drop below zero in the winter while vines are dormant.
  - Because of VdS's moderate temperature plant life cycles in Spring generally start sooner than PM. There are exceptions for specific grape varieties with earlier or later vegetative cycles.
- Seasonal temperature average ranges (the middle numbers, e.g. -4/**0**/**28**/33) were gathered from weatherspark.com in 2021 and are based on data from 1980 to 2016. Regional winegrowers have supplied extreme cold and hot temperatures witnessed (**-4**/0/28/**33**) up to 2021, within specific vineyard zones.
- Temperatures are listed in Celsius (°C) and precipitation in millimeters (mm). (To convert °C to Fahrenheit (°F) multiply °C by 1.8 and add 32. To convert mms to inches multiply mms by 0.0393701.)
- Precipitation levels (listed on maps as an annual average) demonstrate the overall climatic conditions and landscape setting and prompt many considerations. A few examples:
  - Low precipitation: low humidity and low mildew pressure, fewer vineyard treatments needed against mildew and thereby overall easier for ecological and organic viticulture.
  - High precipitation: high humidity and high mildew pressure, so more vineyard treatments are needed against mildew and it's more difficult for ecological and organic viticulture.