China University of Geosciences (Wuhan)

Student Affairs Office of International Education College

Silk Road Doctor Forum

A Quick Recap on Petrography and its Approaches: Rock Description for Research Papers and Thesis

Speaker: Dr. Yomeun Bovari Syprien

Supervisor(s) : Prof. Wang Wei (CUG, Wuhan)
Prof. Tchouankoue Jean Pierre (UYI, Cameroon)

School: School of Earth Sciences

What is Petrography?

Why Petrography ?

What are the approaches to Petrography ?

What are the tools?

What are the characteristics sought in rock?

What are the criteria sought for mineral identification?

How to describe rocks for research papers and thesis?

(https://ts1.cn.mm.bing.net/th/id/RC.d913ad0ed3361cbaf7a6960b9e3da365?rik=7HqeWiqqOkHKaQ&riu=http%3a%2f%2fwww.jotscroll.com%2fimages%2fforums-posts-images%2f1537531125-Types-of-RocksPictures.jpg&ehk=WPLHHzXUYUXJNvOeAuGtmdqn53oymrHQ5t5cn6%2bUz0%3d&risl=&pid=ImgRaw&r=0&sres=1&sresct=1)

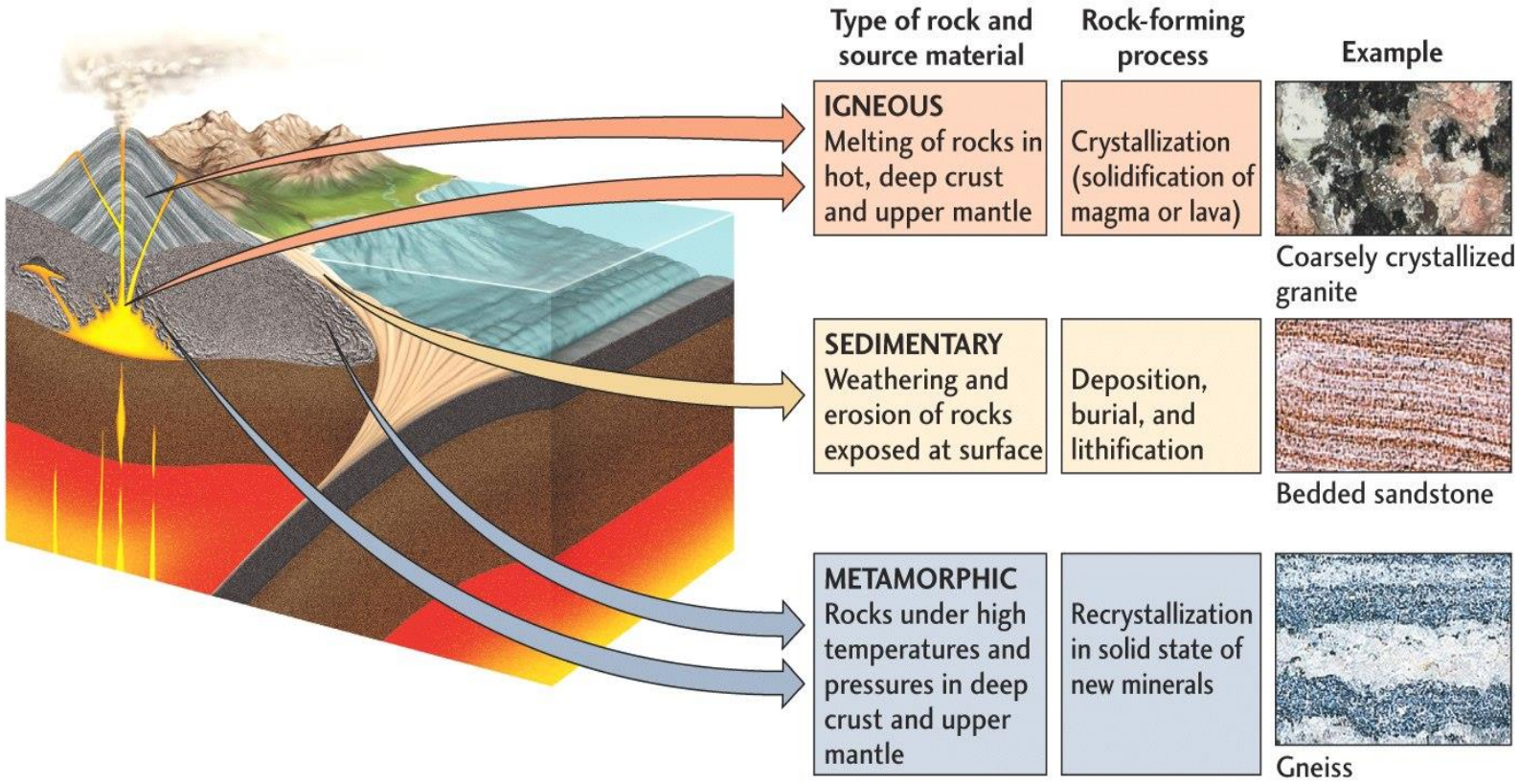
What is Petrography?

Definition

Petrography is a branch that belongs to petrology and general geology, and that basically deals with the **systematic description of geological materials,** which are **rocks**. The description consists of analyzing the **composition** (mineral composition), the **organization** (texture and structure), and all the **physical properties** of rocks and giving them a **name** and a **classification** in **hand specimens** and **thin sections**.

Why Petrography ?

Importance and applications of petrography



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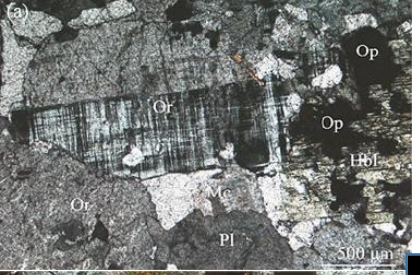
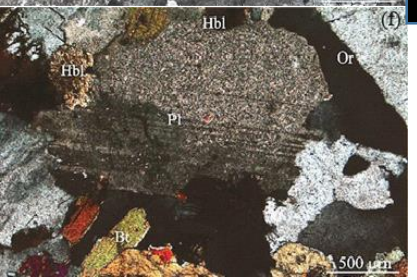
Fundamental geology

Petrography is a basic tool that helps in **understanding the materials of the earth's crust** through the analysis of their physical and visual properties.

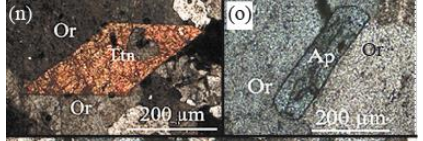
Knowing a region's geological past requires a grasp of petrography. Petrographers can determine the **processes that generated rocks and the environmental conditions that prevailed during their creation** by examining the mineral content, texture, and structure of rocks. With the aid of this data, scientists may piece together the **chronological order of geological occurrences, including the kind and degree of deformation, the kind of climate, and the sediment source**.

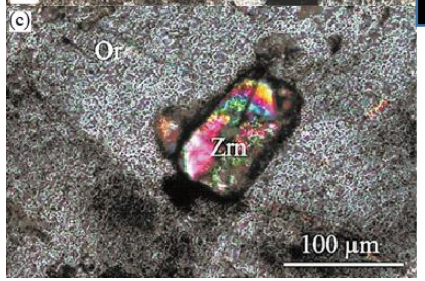
Petrography is a mature technique that makes the **transition between field and laboratory studies**. It is often used in conjunction with instrumentally more advanced methods of materials analysis, such as chemical analysis (e.g., NAA, ICP-MS) and scanning electron microscopy (SEM) (Whitbread, 2016).





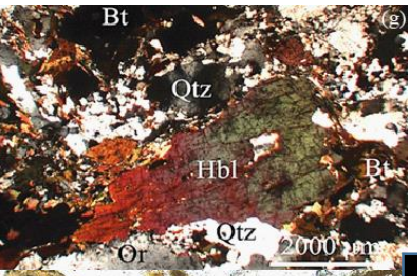
K-Ar and Ar-Ar dating

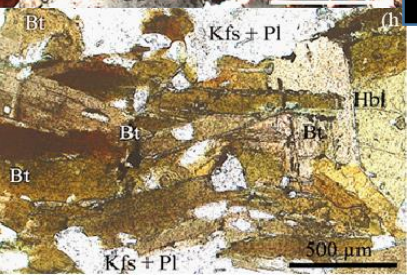




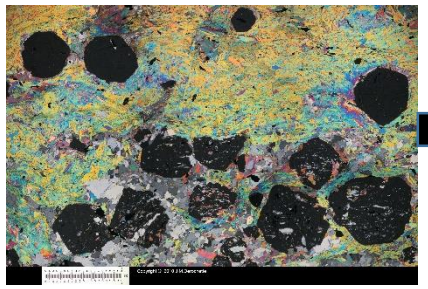
U-Pb dating for Ttn, Ap and Zrn; Lu-Hf for Ap

Petrography can give **ideas on the appropriate methods for geochronology analyses**, since they are chosen and applied on specific minerals.

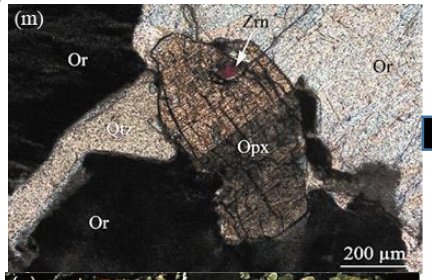




K-Ar and Ar-Ar dating

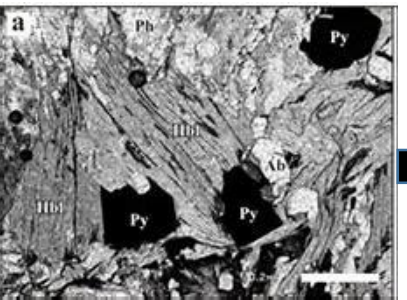


Lu-Hf dating

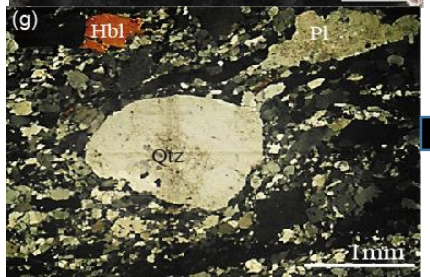


Ar-Ar, Sm-Nd and Rb-Sr dating

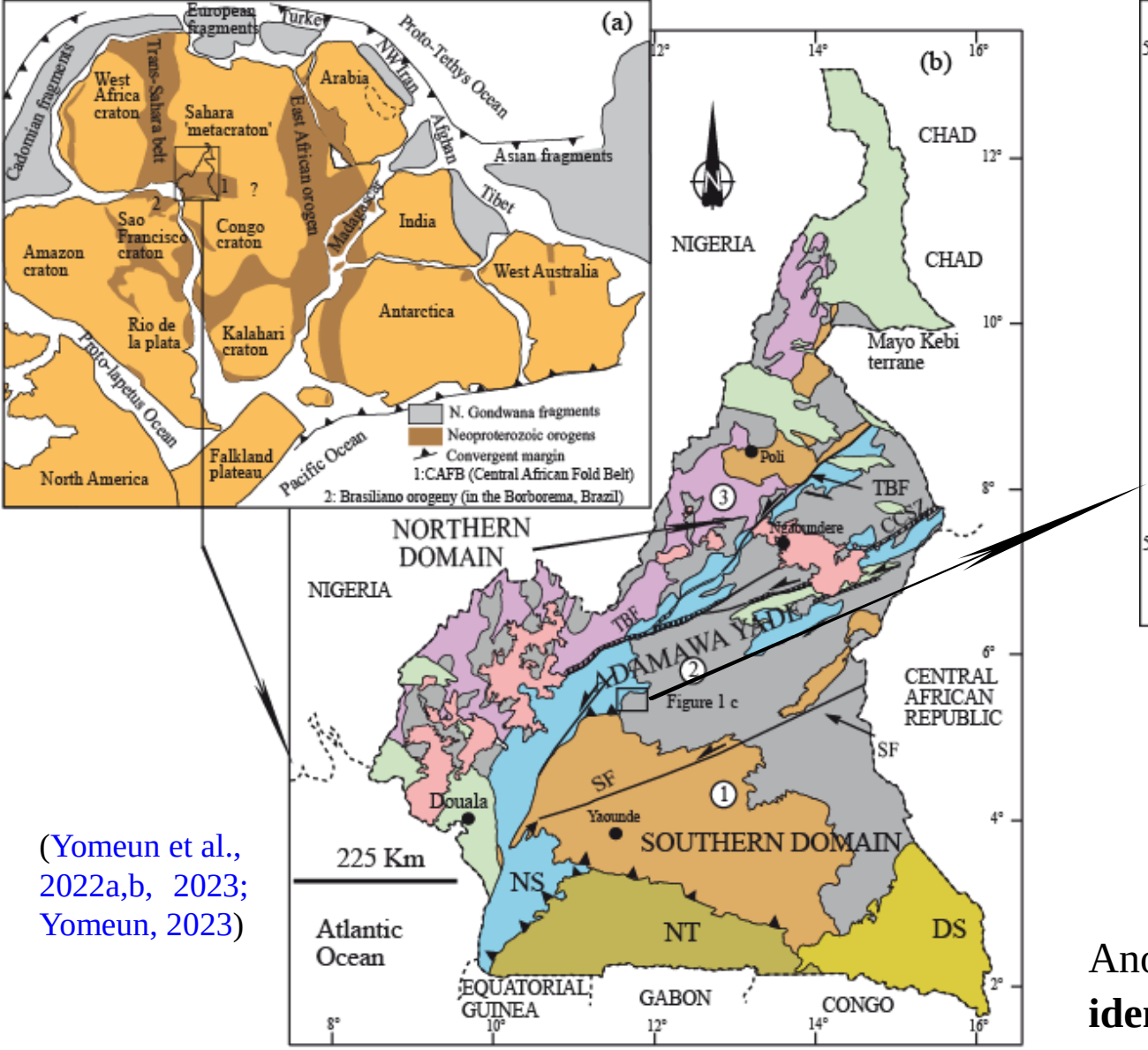
(Yomeun et al., 2022a,b, 2023; Yomeun, 2023; https://ts1.cn.mm.bing.net/th/id/R-C.6ce06360b05c77c5a1a067691c3ff4c5?rik=Otz5FLPuT87iiA&riu=http%3a%2f%2fjm-derochette.be%2fimages%2fWF_1%2fPg3_27_LPA_I.jpg&ehk=%2bjf3R7Mismbk52L0KY%2bU85picNIBRj%2bM6e48wjFnvdI%3d&risl=&pid=ImgRaw&r=0; https://tse2-mm.cn.bing.net/th/id/OIP-C.ymphRtli-lXRsVSfxzat8QHaCy?w=350&h=115&c=7&r=0&o=5&dpr=1.3&pid=1.7)



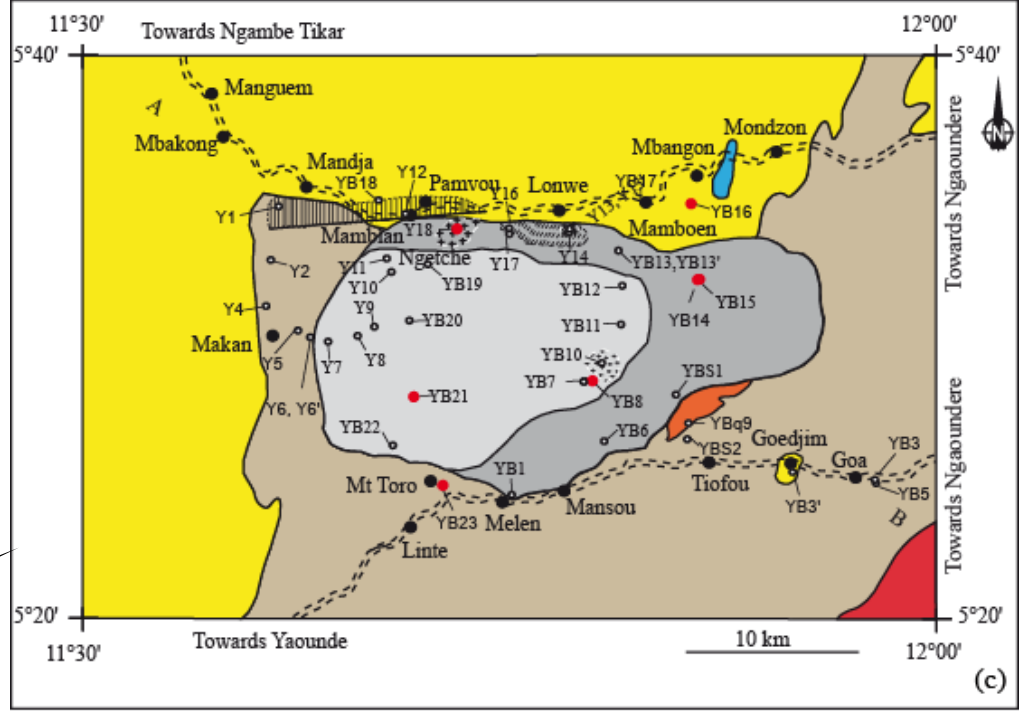
Re-Os dating



Ar-Ar dating



(Yomeun et al., 2022a,b, 2023; Yomeun, 2023)



THE LINTE SYENITIC MASSIF AND SURROUNDING ROCKS

Linte syenitic massif
- Coarse grained syenite
- Medium grained syenite
- Coarse grained monzonite
- Medium grained monzonite
- Cataclastic to porphyroid granular syenite and monzonite

Surrounding rocks
- Mylonite
- Anatexite
- Amphibolite
- Orthogneiss
- Syn-tectonic granitoid
- Late Syn-tectonic granitoid

- Secondary road
- Fault
- Locality
- Sampling point
- Dated sample

CAFB: Central African Fold Belt
- Cenozoic volcanic rocks
- Cretaceous to Paleogene sedimentary cover
- Syn to post tectonic granitoids (500 - 600 Ma)
- Pre to syn to tectonic granitoids (600 - 660 Ma)
- Meso to Neoproterozoic volcano-sediments (700 -1000 Ma)
- Yokadouma and Dja series (age unknown)
- Paleoproterozoic gneiss and orthogneiss (2100-1900 Ma)
- Ntem complex (3000-2900 Ma)
- Figure 1 c
- Fault
- Thrust fault
- Strike slip fault
- Country border

Another advantage of petrography is that the **rocks and minerals identified can be further explored through geological literature and maps** for the region under study, both of which are **significant aids in studying raw material procurement patterns and the provenance of artifacts.** It helps to **improve existing geological maps or map out geologic formations**.

Applied geology

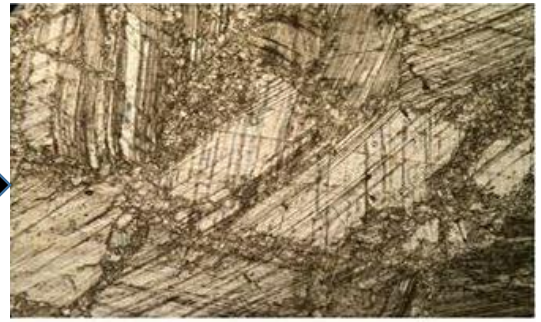
Petrography can be used to **identify, select, and classify particular types of rocks used as construction materials and define appropriate types of rocks on which and/or where important infrastructure such as bridges, buildings, and houses could be established**.

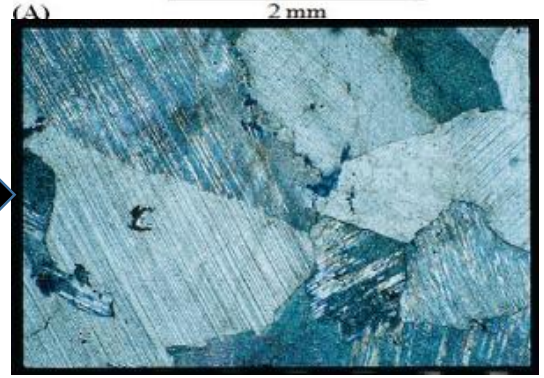
(https://radzimaphoto.com/wp-content/gallery/photo-of-the-day/Old-Stone-Road-Bajary-Mjadzjel-District-2013-2013122-.jpg)

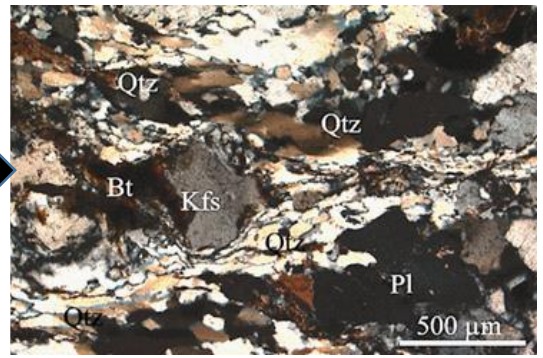
(https://tse4-mm.cn.bing.net/th/id/OIP-C.NVtWl8Z52J1nTYDOzvoGUwHaE6?rs=1&pid=ImgDetMain)

(https://www.buechelstone.com/wp-content/uploads/2019/11/Classic-ranch-stone-house-exterior-design-with-Chilton-Rustic-stone-cladding-thin-veneer-siding-HERO-1280x660-48bb.jpg)

(https://i0.wp.com/civiconcepts.com/wp-content/uploads/2021/10/13-Types-of-Stone-Used-In-Construction.jpg?w=900&ssl=1)

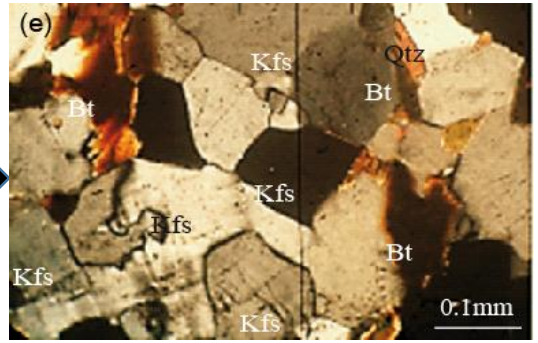






Determining **suitable rocks for the industries of cement and ceramic**

The good adherence of lime stones and dolomites to cement and bituminous binder makes them appropriate. The chalk is not fit for use in buildings. Although quartzite has a strong bond with cement, it has a weak one with bitumen (Susmita, https://www.engineeringenotes.com/engineering-materials-2/reinforced-cement-concrete).



(Yomeun et al., 2022b; 2023; Yomeun, 2023; https://www.researchgate.net/profile/Sengpasith-Houngaloune/publication/279763008/figure/download/fig1/AS:367473451913217@1464623906831/Photomicrographs-of-limestones-thin-section-A-L-B-B-L-V-C-L-L-and-D-L-O.png; https://www.wardsci.com/stibo/bigweb/std.lang.all/90/75/10309075.jpg; https://wserv3.esc.cam.ac.uk/p1acollections/files/square_thumbnails/5ef179694fabe2f138284ddd124cda39.jpg)

(https://www.geostru.eu/wp-content/uploads/2016/06/Landslide-On-The-Mountain-Road-1600x800.jpg)

(https://www.lynx-global.com/data/galeri/ea3974d2e2906ead727247eef85d70e5.jpeg)

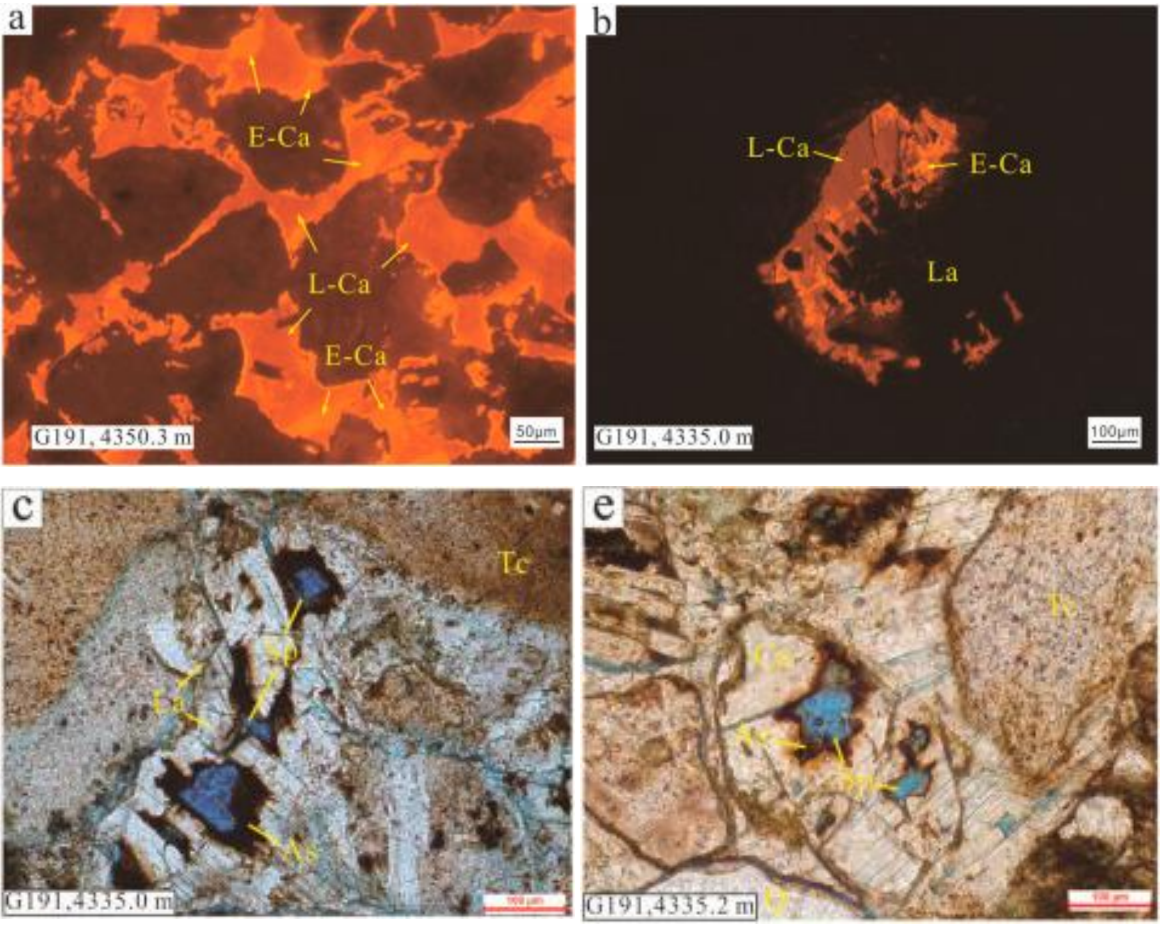
(https://www.americanexchange.com/wp-content/uploads/2020/08/open-pit-mining.jpg)

(https://i0.wp.com/geologypics.com/wp-content/uploads/2017/11/170523-96.jpg?ssl=1)

Petrography analysis is used in geotechnical and mining engineering to **analyze the types of rocks in order to define the stability and mechanical behavior of slopes in roads, open pit mines, and tunnels in underground mines.**

Determining **lithologies that can store water or hydrocarbons**, lithologies that can be associated with different **mineral, metallic and non-metallic deposits**. The knowledge of pore-related features and cracks is **essential in the investigation of reservoirs and places of mineralization**.

Petroleum exploration relies heavily on petrography. Petrographers can determine the **composition, porosity, and permeability of petroleum reservoirs** by examining the mineral content, texture, and structure of rocks. The location and development of petroleum resources, as well as the optimization of production and improvement of recovery, can all be decided upon with the use of this information.



Cathodoluminescence images of calcite cement between sandy conglomerate grains, (a) early-stage calcite is bright orange, and late-stage calcite is dark orange in an oil layer sample; (b) the dark orange indicates late-stage calcite cement, whose edge filled the dissolution pores of nonluminous laumontite along cleavages in oil layer samples. Note: E-Ca - early calcite cement; L-Ca - late calcite cement; La - laumontite (Zhi et al., 2022).

(c) irregular dissolution pores co-exist in laumontite cements with black asphalt, which records hydrocarbon charge; (e) sparry calcite cements are dissolved, forming irregular secondary pores, at the edge of which residual black asphalt and oil exists in a sandy conglomerate in an oil layer. Note: La-laumontite; Ca-calcite; Tc-tuffaceous debris; Q-quartz; Pp-primary pore; As-asphalt; Ac-andesite debris; Sp-secondary pore (Zhi et al., 2022).

What are the approaches to Petrography ?

Petrography techniques

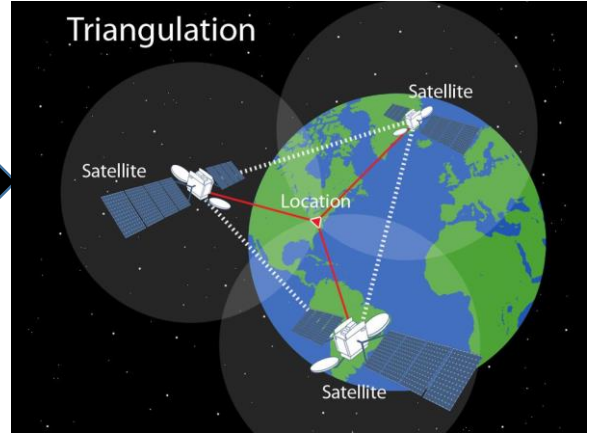
Petrography investigation includes **two analytical techniques** based on the nature of the study portion of rock and the instrumentation (Whitbread, 2016). It comprises:

- **Macroscopic (hand specimen and outcrop) analysis** and
- **Microscopic (thin section) analysis**.

Macroscopic petrography

What are the tools?

GPS



Geologist's hammers and chisels

Geologist's compass

Macroscopic analysis of minerals and rocks is performed through **eye-scale observation of the** outcrop and fresh surface, broken or not. In addition to **eyes**, basic tools such as a **hand lens** (approximately 10×) could be used to improve the acuity and visibility, a **hardness pencil**, 10% **hydrochloric acid**, a **magnet**, a **geologist's hammer** and **chisel**, **measuring tapes, and** a **GPS** to mark the location, which will also help in building or updating geological maps.

(Yomeun et al., 2023; Yomeun, 2023; https://media.nationalgeographic.org/assets/photos/000/282/28251.jpg)

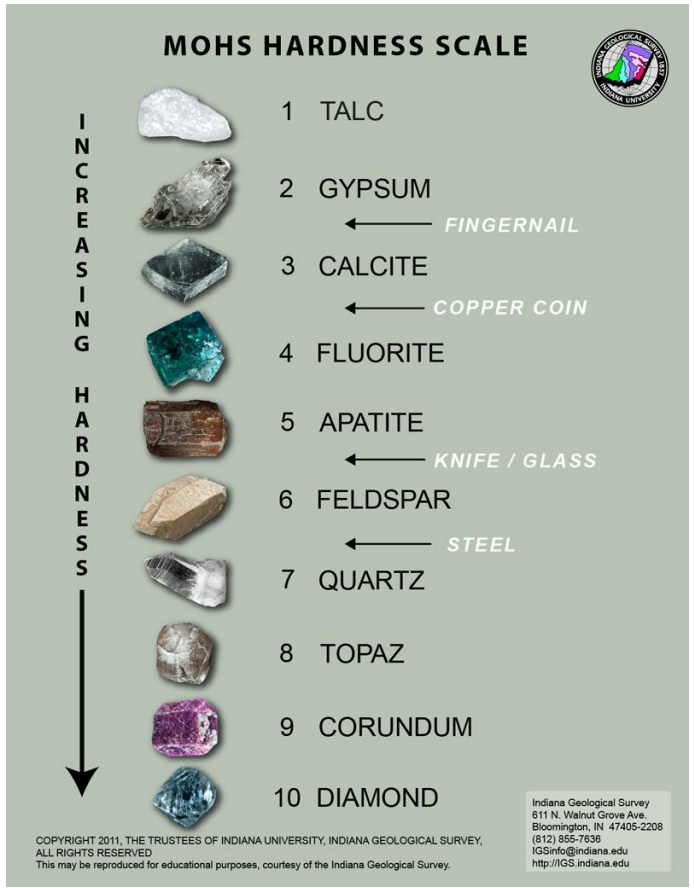
(https://image.freepik.com/free-vector/gps-system-with-satellites-around-earth_1308-31409.jpg)

Hand lens

(https://c8.alamy.com/comp/CEE795/a-geologist-examines-a-rock-sample-using-a-hand-lens-in-the-field-CEE795.jpg)

(https://www.geologypage.com/wp-content/uploads/2016/04/Mohs-scale-of-mineral-hardness-GeologyPage.jpg)

Hardness pencils



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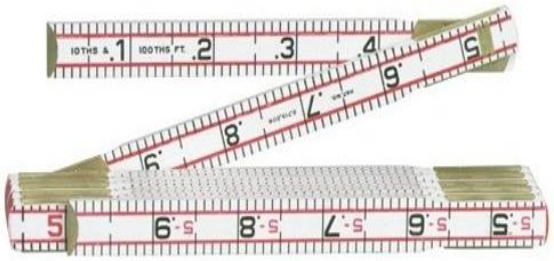
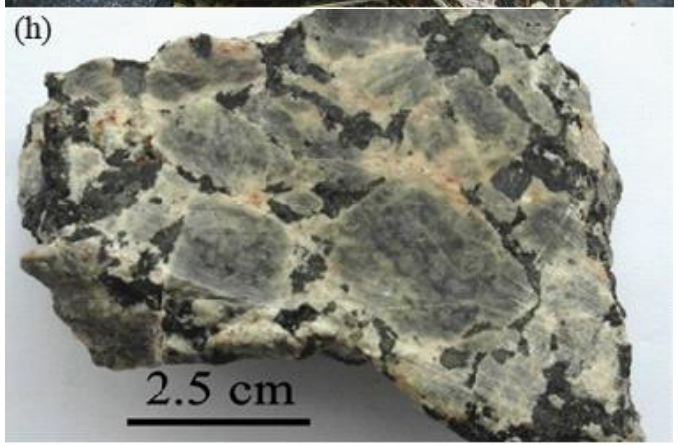
Magnet pencil

Magnet

hydrochloric acid



Measuring tapes



(Yomeun et al., 2022a; Yomeun, 2023; https://geologypics.com/wp-content/uploads/2020/11/201111-17.jpg)

What are the macroscopic characteristics sought in rock?

The most important features observed

The characterization of rocks starts with macroscopic analysis, which seeks to pinpoint the **salient characteristics** that are visible to the naked eye, such as:

- **Color** (intimately associated with the mineralogical composition and, essentially, to impurities present in the minerals or in the rock (Frasca, 2018) and the weathering)

- **Fabric** (**structure or texture**, which referred to the physical organization or arrangement of rocks and their different constituants), and

- **Mineral composition** (through mineral identification).

What are the macroscopic criteria sought for mineral identification?

Macroscopic characteristics of **minerals**

Since the macroscopic analysis is based on physical properties, the following criteria are used for mineral identification:

Color: Light or Dark color

(https://tse3-mm.cn.bing.net/th/id/OIP-C.u8Ko_jausVyna7oh0To3OwHaF7?rs=1&pid=ImgDetMain)

(https://geologyistheway.com/wp-content/uploads/2021/07/1280px-Biotite_mica_2_31739438210.jpg)

Luster: Metallic or non-metallic (glassy or vitreous, silky, milky, resinous, pearly, earthy) luster

(https://cdn.britannica.com/52/100752-050-784C6A3D/Pyrite.jpg)

(https://www.gemstonebuzz.com/wp-content/uploads/files/gemstone/feldspar.jpg)

Hardness

(https://www.geologypage.com/wp-content/uploads/2016/04/Mohs-scale-of-mineral-hardness-GeologyPage.jpg)

Cleavage and fracture

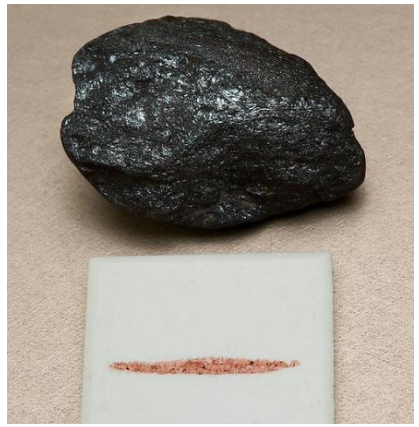
(https://elmelin.com/wp-content/uploads/2018/09/Nanta-aom1.jpg)

(https://geologyistheway.com/wp-content/uploads/2021/07/1280px-Biotite_mica_2_31739438210.jpg)

Streak: a color left behind when a mineral is rubbed against an unglazed porcelain tile. Minerals with a hardness of up to 7 do not leave streaks on unglazed porcelain tile.

(https://ssl.c.photoshelter.com/img-get/I0000gS8Q6uXxNxY/s/750/750/pyrite-streak1.jpg)

(https://www.ga.gov.au/__data/assets/image/0012/60231/gold-image4by800.jpg)



(https://m.psecn.photoshelter.com/img-get/I0000OQubkG39MFg/s/750/750/hematite-streak-1.jpg ; https://media.sciencephoto.com/image/c0440274/800wm/C0440274-Magnetite_streak_test.jp)

Special characteristics

Magnetic characteristic

(https://www.alamy.com/aggregator-api/download?url=https://c8.alamy.com/comp/2DF790D/magnetite-is-an-iron-oxide-mineral-with-magnetic-properties-sample-attracting-metal-objects-2DF790D.jpg)

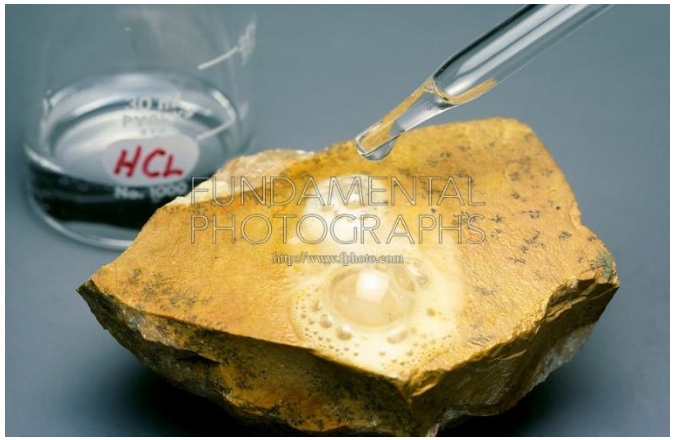
Salty taste characteristic

(https://inspiritcrystals.com/wp-content/uploads/2018/03/IMG_4922.jp)

Rotten eggs smell-like characteristic

(https://ts1.cn.mm.bing.net/th/id/R-C.e26a2f85be017d80bbf1c956a4ebd88e?rik=UllJSzShc62ILg&riu=http%3a%2f%2fwww.periodictable.com%2fSamples%2fSC.NativeSulfur%2fs13.JPG&ehk=%2fHgE0K9FaGWUxYGF3XIJkf%2bh88Yi5qJfDz2q2Sckwlc%3d&risl=&pid=ImgRaw&r=0)

Effervescence when treated with **hydrochloric acid**



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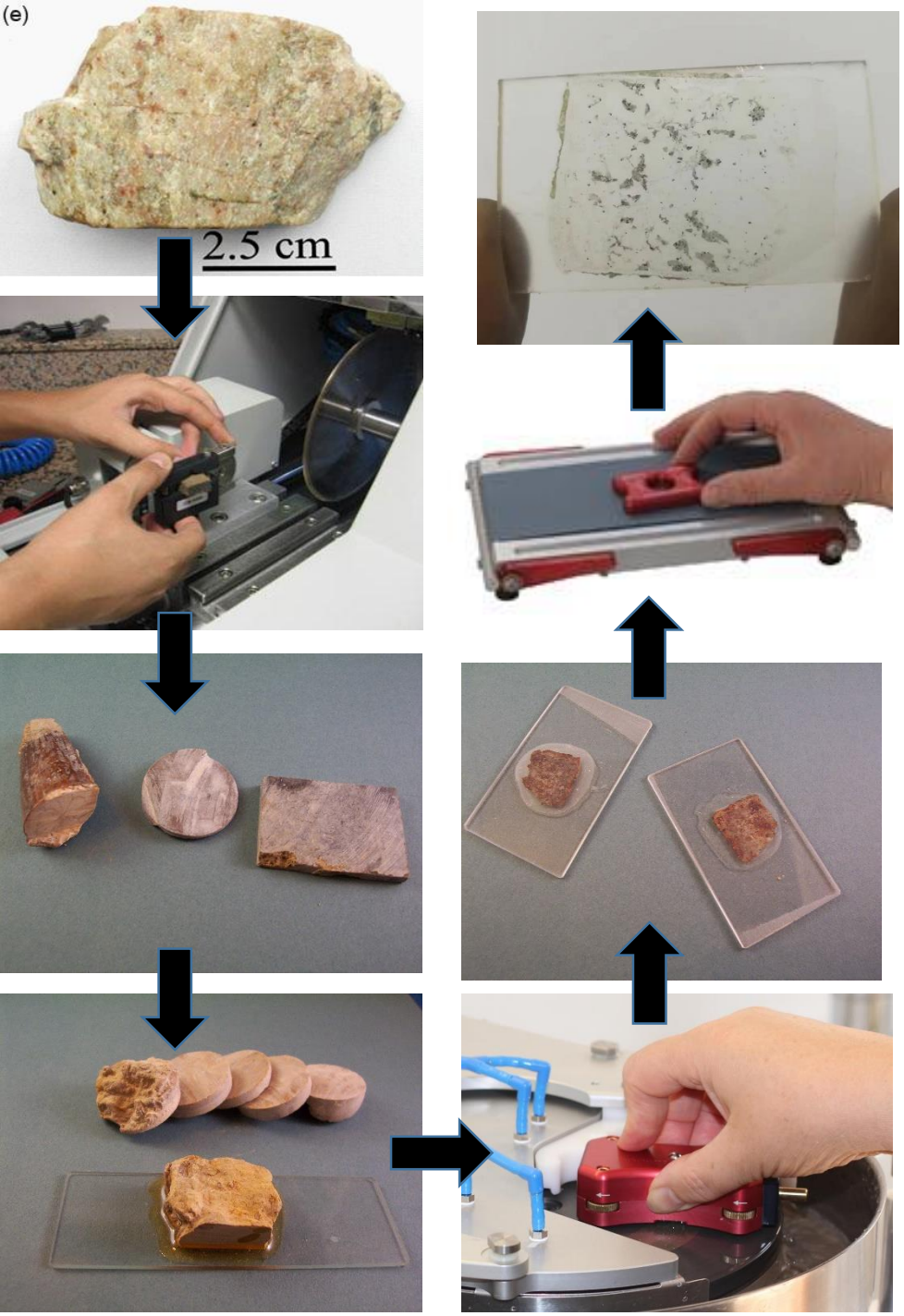


Microscopic petrography

What are the tools?

Microscopic analysis requires the laboratory preparation of **thin sections of** rock samples and their observation under a **polarizing (or petrological) microscope.**

Thin sections are prepared by grinding a flat surface on the sample and bonding it to a glass slide (measuring either 75 - 25 mm or 46- 27 mm). The mounted sample is ground to a standard thickness, usually 0.03 mm, at which point it either receives a concluding fine polish or is protected by the attachment of a glass coverslip (Nesse, 2004). At this thickness (30 µm), many common minerals are translucent and can be identified by optical effects when light is refracted through them (Whitbread, 2016).

(Yomeun et al., 2022b; Yomeun, 2023; https://www.kemet.co.uk/images/blog/thin-section-preparation-of-rocks.jpg; https://ts1.cn.mm.bing.net/th/id/R-C.7a0c4786c98e75a4ffdaeaba555b0772?rik=VAU0YpNkiCJ3GQ&riu=http%3a%2f%2flpl.arizona.edu%2f%7erhill%2ffossil%2fthin-sect%2fimage018.jpg&ehk=ODIzUNmwhKBF%2b488yQIG0OXNaA%2ffgXfJqB%2f6MQmqnrU%3d&risl=&pid=ImgRaw&r=0; https://www.lpl.arizona.edu/~rhill/fossil/thin-sect/image008.jpg; https://thin-section.com/images/Principle/Grinding-Disc-B.jpg; https://thin-section.com/images/Principle/Petrographic-Thin-Section-Preparation-B.j)

Polarizing (or petrological) microscope

Polarizing (or petrological) microscope

The thin section is placed on a rotating stage above the microscope light source. Light reaching the thin section is polarized by a filter (the polarizer) beneath the stage so that it only vibrates in one direction. This light is refracted as it passes through most minerals in the thin section. A second polarizing filter is situated above the sample, between the microscope objective lens and eyepiece. This filter (the analyzer) is set at 90° to the polarizing filter below the stage, but it can be moved in and out of the light path.

When the analyzer is inserted into the light path with no sample on the stage, it blocks out all light from the polarizer so that the observer sees only darkness. With a mineral sample on the stage, transmitted light is refracted, and in most cases, the vibration direction is split and twisted slightly (double refraction) so that the analyzer does not cancel out all the light (Whitbread, 2016).

What are the microscopic characteristics sought in rock?

Important features of rock:

- Texture

- Detailed mineralogical composition

- Microstructure

What are the microscopic criteria sought for mineral identification?

Microscopic characteristics of **minerals**

Examination of the thin section through a polarizing microscope takes place under plane-polarized light (analyzer removed) and crossed-polarized light (analyzer inserted) to have much more details and accurate precision in identifying minerals, determining mineralogical compositions, and examining microstructures.

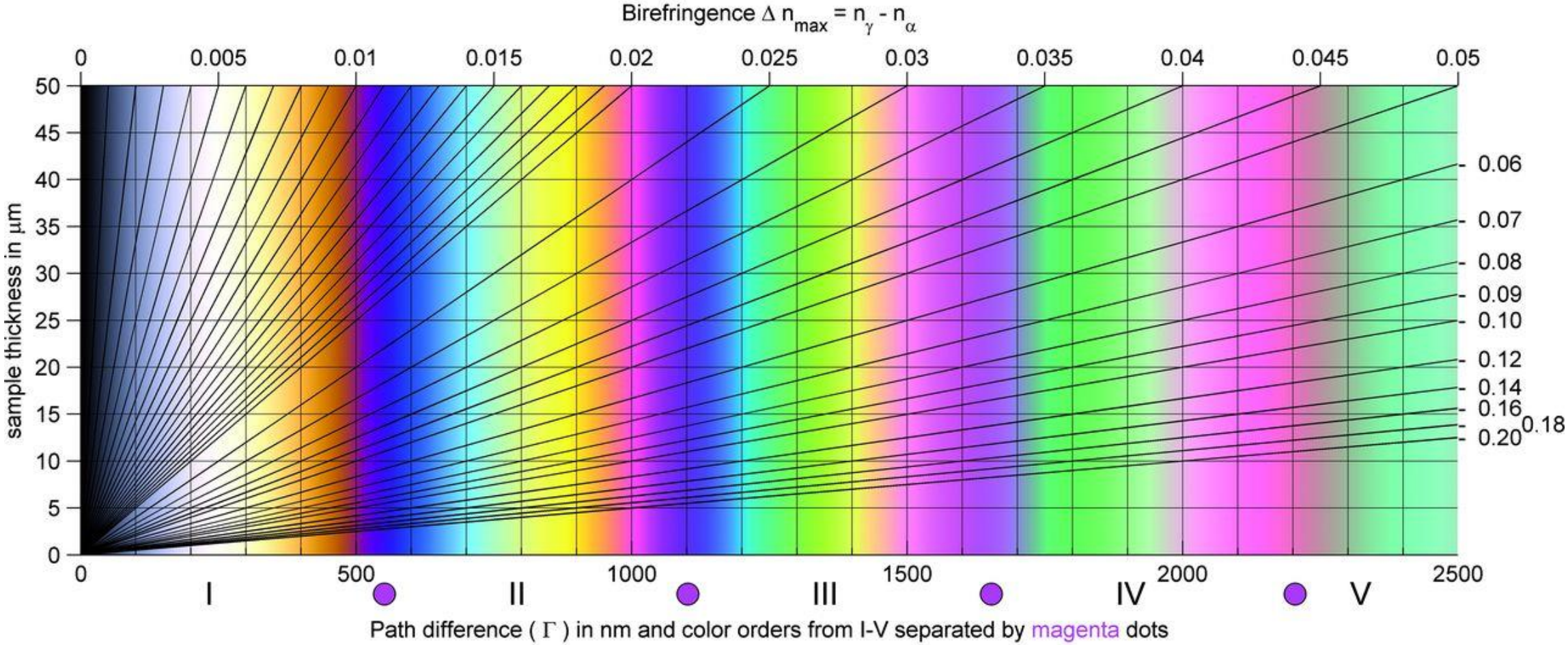
The features observed in **plane-polarized light** include

- **Color**
- **Pleochroism**: changes in color on rotation,
- **shape**,
- **Cleavage and fracture**,
- **Relief** (refractive index)
- **Inclusions**,
- **alterations**.

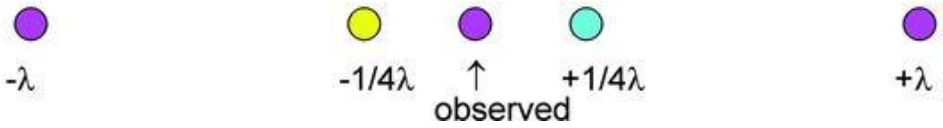
Under **crossed polarizers**

- **Extinction** behavior,
- **Interference colors**
- **Twinning and zoning**.

Calculated Michel-Lévy Colour Chart



Aid for using 1/4 λ and 1 λ compensator plates
transfer to transparent slide and use on chart with the observed dot in center



How to describe rocks?

Required Information and organization

The **location**, **classification, and name** of rocks are sometimes given in the introductory words (once for both macro- and microscopic descriptions) just before the strict sense description. Petrographic classification of rocks takes into consideration the mineralogical composition, typically in conjunction with other factors like grain size or structure. However, there is not a universal classification for all types of rocks, as each is based on a separate set of standards according to various authors or institutions (Frasca, 2018). (e.g., Le Bas and Streckeisen, 1991; Shelley, 1992; Le Maitre, 2003; and the IUGS classification for igneous rocks, Folk, 1962; Dunham, 1962; Pettijohn, 1975; Pettijohn et al., 1987; Carozzi, 1993; classification for sedimentary rocks, Bucher and Grapes, 2011 classification for metamorphic rocks

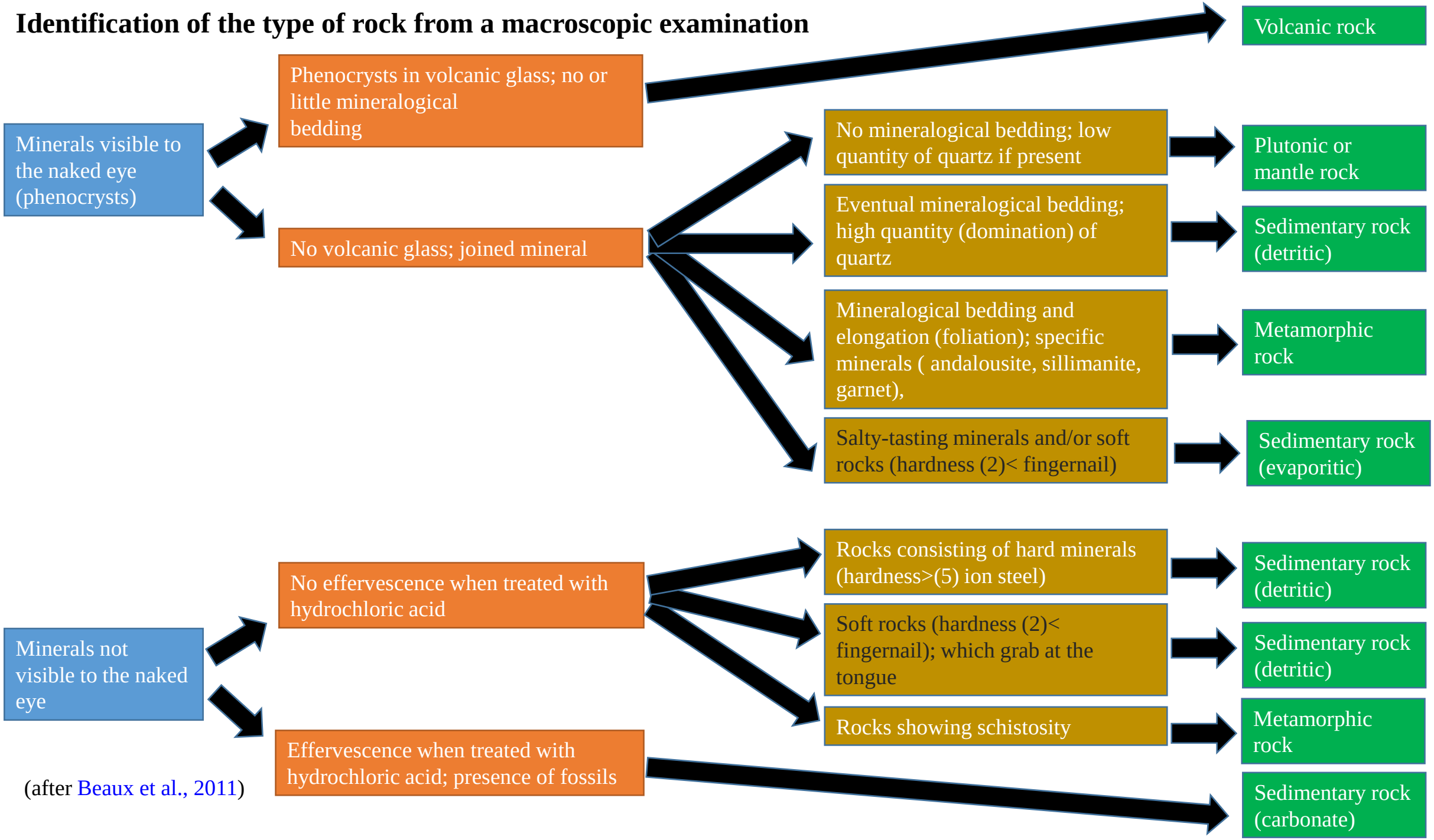
Macroscopic description of rocks

Extension of the outcrop (which could be illustrated on the geologic map)
Shape and size of the outcrop
And other relevant **characteristics that may be visually observed.**

Color of rock
Texture: Organization of particles in rock and their mutual intergranular relationships
Mineralogical composition, grain shape and size, and other **relevant characteristics** that may be visually observed such as **weathering**…

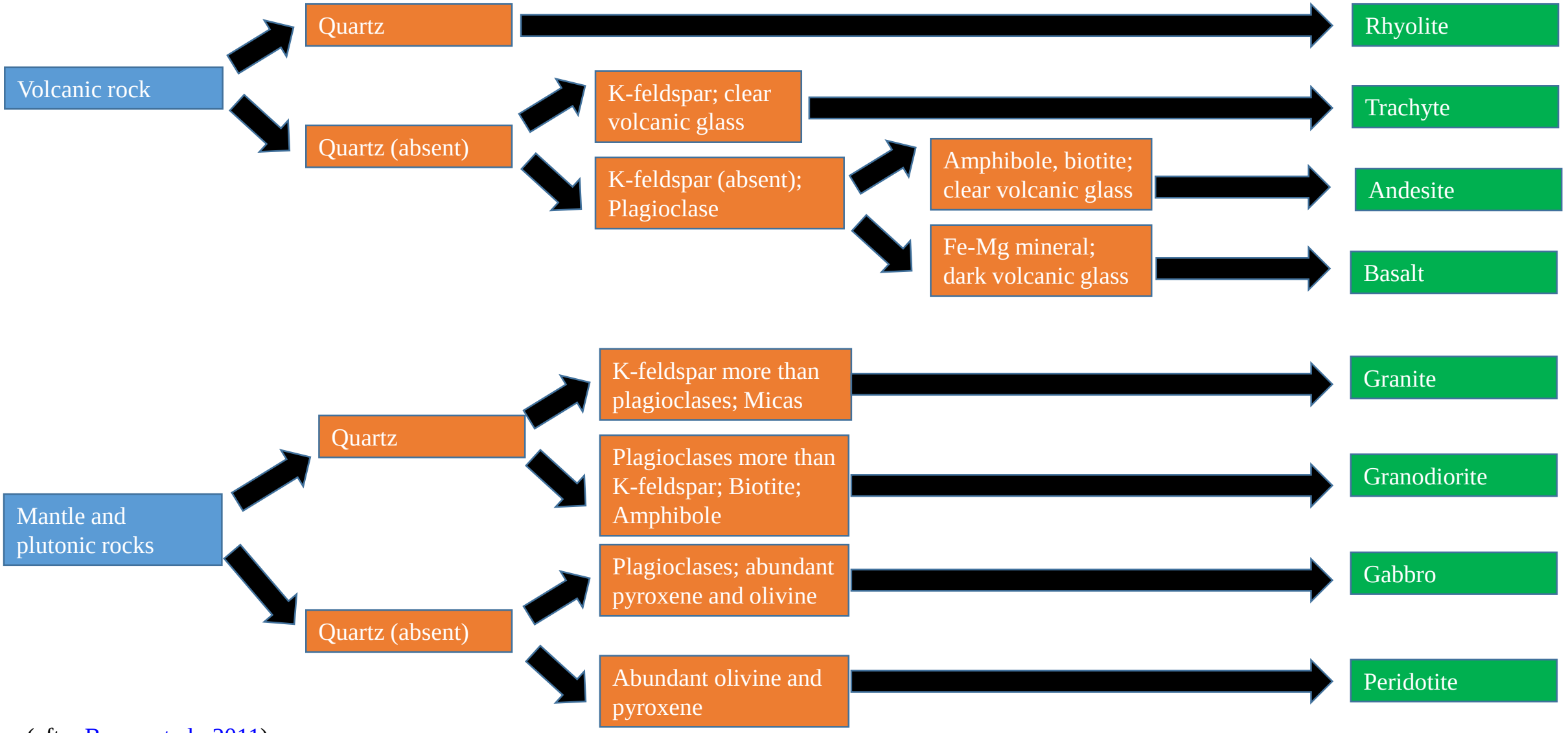
Good and clear illustrative pictures with **scale and international-approved** (e.g., Le bas and Streckeisen, 1991; Whitney and Evans, 2010; Warr, 2021) or and recommended **labels (**IUGS)

Identification of the type of rock from a macroscopic examination



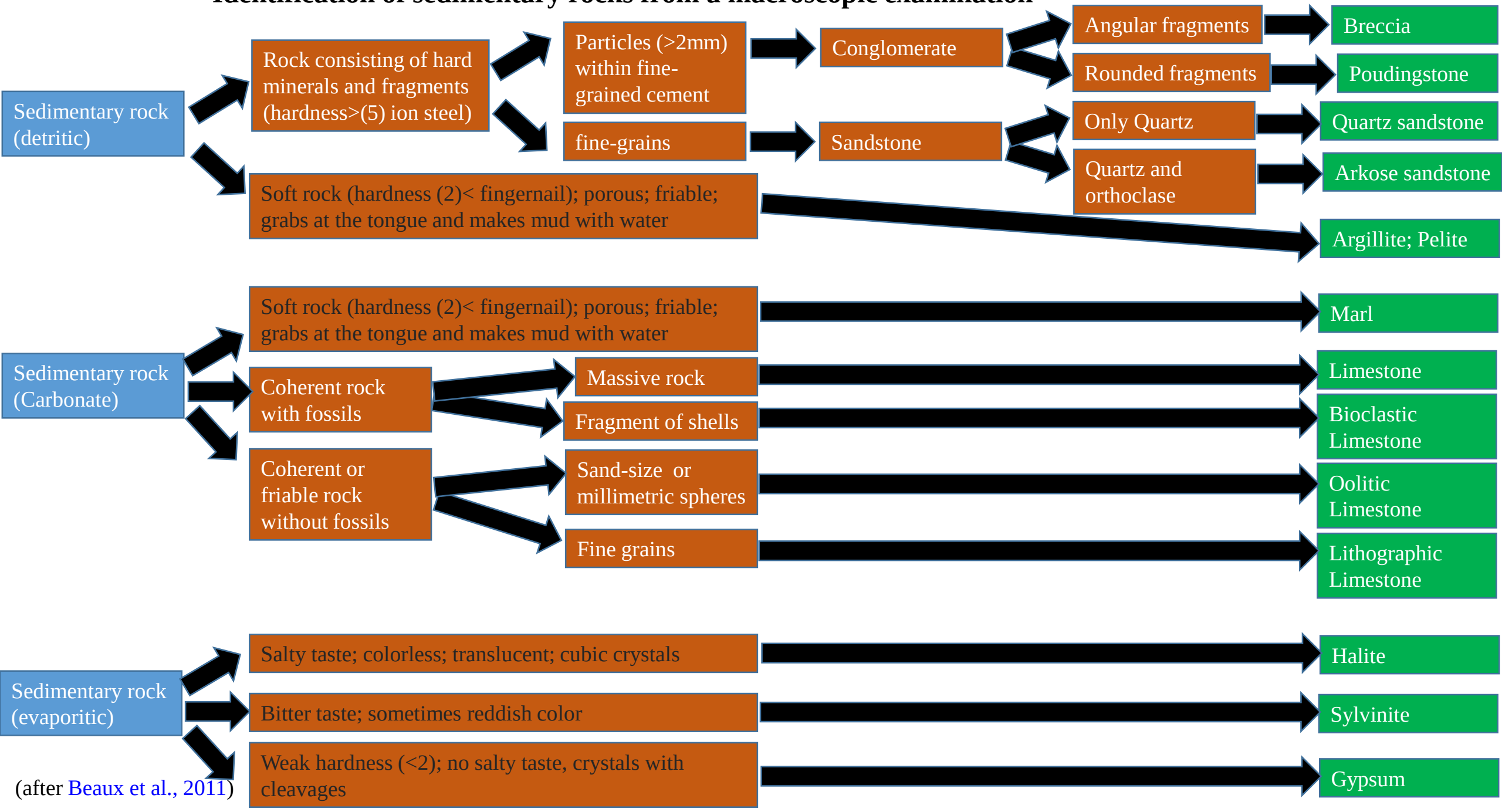
(after Beaux et al., 2011)

Identification of mantle and magmatic rocks from a macroscopic examination



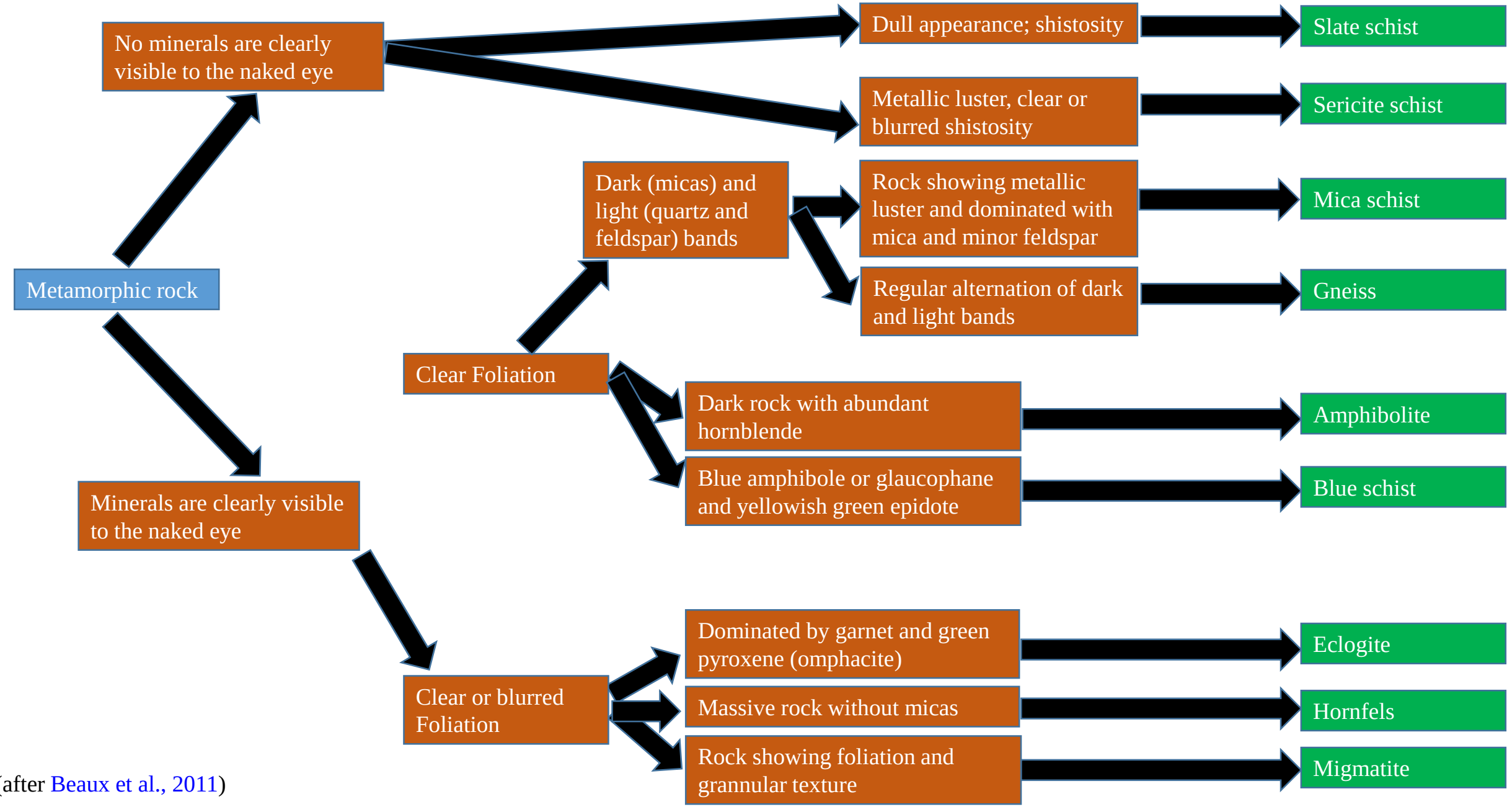
(after Beaux et al., 2011)

Identification of sedimentary rocks from a macroscopic examination



(after Beaux et al., 2011)

Identification of sedimentary rocks from a macroscopic examination



(after Beaux et al., 2011)

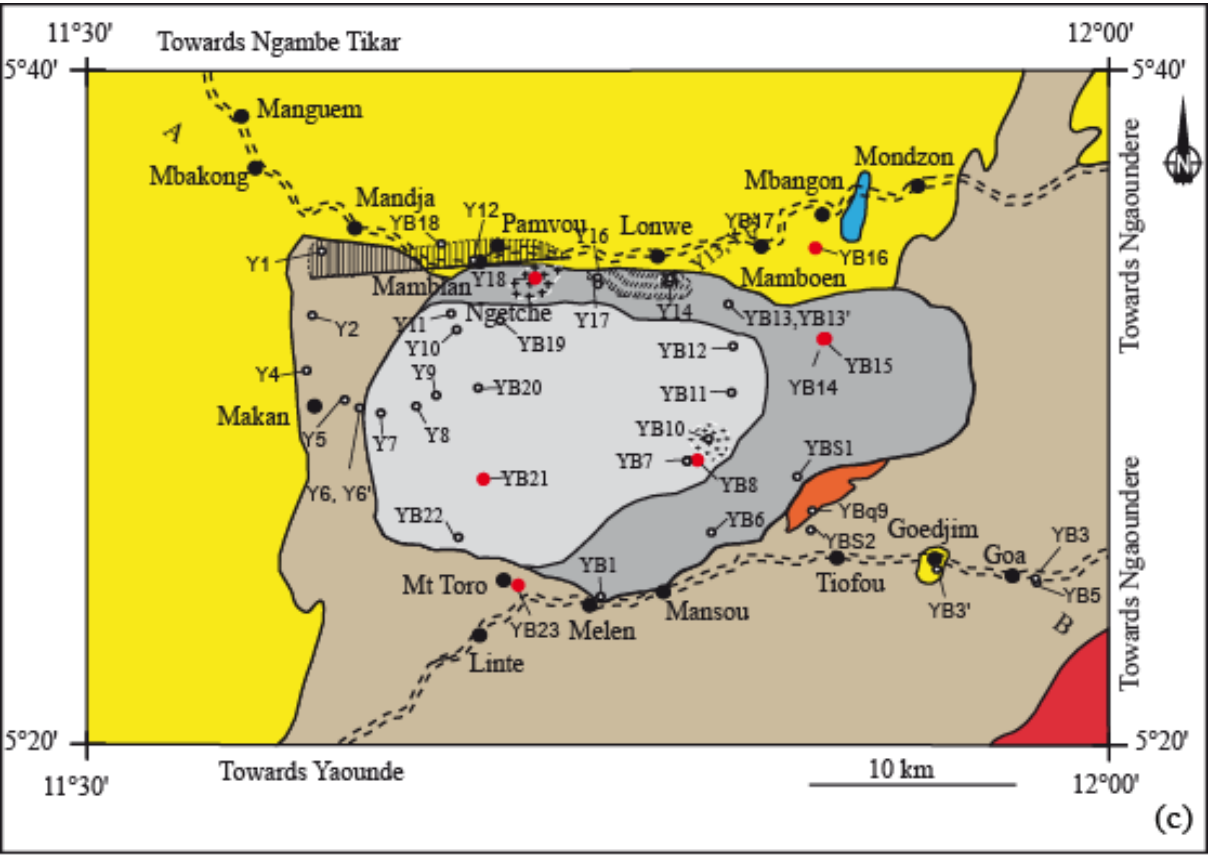
Microscopic description of rocks

The needed information is the same as in the case of macroscopic analysis (except the size, shape, and extension of the outcrop and color of rocks); however, with much more **details and accurate precision** in**:**

Determining mineral compositions (size, shape, and quantitative evaluation (% vol.), inclusions, and alteration) and

Examining microstructures enabled by a polarizing microscope.

Description of rocks: An example



THE LINTE SYENITIC MASSIF AND SURROUNDING ROCKS

Linte syenitic massif
- Coarse grained syenite
- Medium grained syenite
- Coarse grained monzonite
- Medium grained monzonite
- Cataclastic to porphyroid granular syenite and monzonite

Surrounding rocks
- Mylonite
- Anatexite
- Amphibolite
- Orthogneiss
- Syn-tectonic granitoid
- Late Syn-tectonic granitoid

- Secondary road
- Fault
- Locality
- Sampling point
- Dated sample

Information

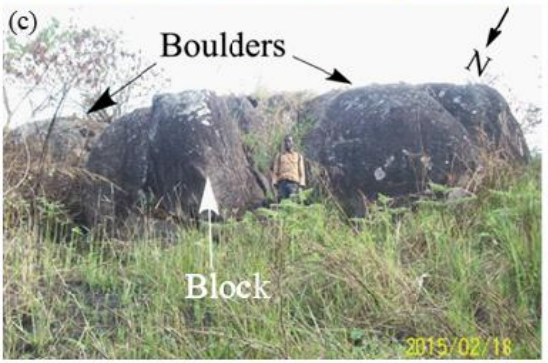
Extension of outcrop

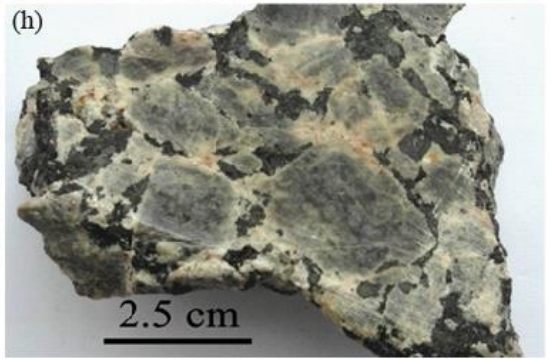
Classification and name of rocks

Introductory words or introduction

The study area (5° 20' to 5° 40' N and 11° 30' to 12° 00' E) in the central part of Cameroon, Adamawa-Yade domain of the CAFB, is constituted of a syenitic batholith, outcropping among migmatites and granitoids (Fig. 5.1). This area covers a surface of about 2054 km^2. The syenitic batholith, also called the Linte syenitic massif, is elliptic (E-W elongated) and occupies an area of ca. 360 km^2 (Yomeun et al., 2022 b). This chapter focuses on detailed petrographic features

Syenite is the dominant rock type in the Linte massif followed by monzonite (Fig. 5.2). Joints and granitic veins and/or dykes locally crosscut mainly undeformed rocks. They are granular porphyritic and medium- to coarse-grained. Locally, these rocks show incipient deformation and development of protomylonites with granular to subequigranular textures (Fig. 5.1).





Information

Extension of outcrop

Shape and size of outcrop

Color of rocks

Texture

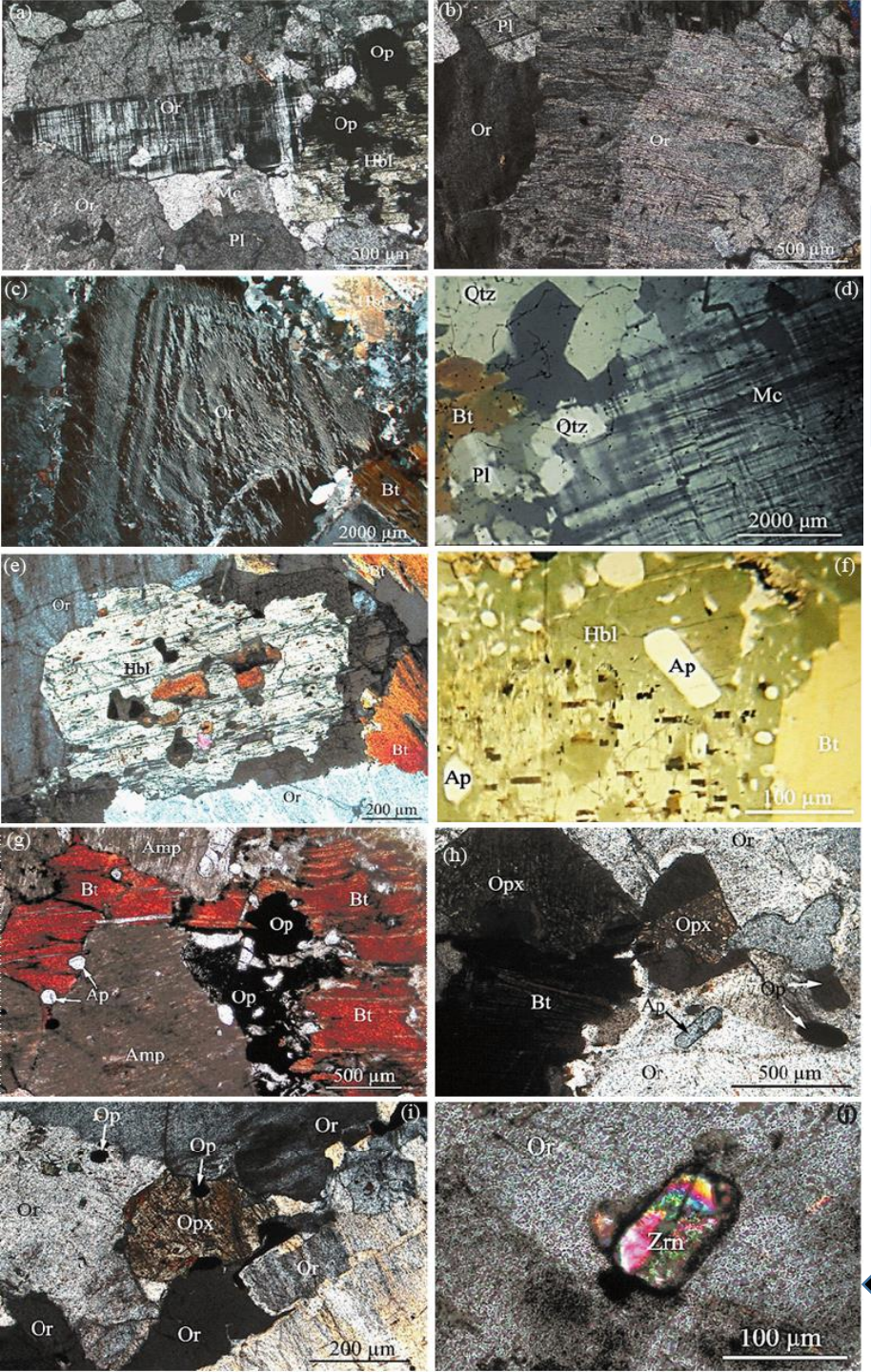
Mineral composition, grain shape and size and other relevant characteristics

Clear pictures with scales

Macroscopic description of rocks: An example

Coarse-grained syenites:Outcrops and lithology

At large scale, coarse grained syenites show a horseshoe or fork shape covering the southern, northern, and eastern parts of the batholith (Fig. 5.1). They outcrop as domes and slabs of several tens of meters (Fig. 5.3a-b), boulders, and blocks with sizes varying from centimeter to several tens of meters (Figs. 5.3c-e). They are malgachitic (or larvikitic), but dominated by dark gray to pinkish (Figs. 5.3f-g), purplish gray, and gray (Fig. 5.3h) colors. These rocks are characterized by a granular porphyritic texture (Fig. 5.3f-h). Feldspar crystals are dark to pinkish purple in color, less to more shimmering, more often euhedral, haphazardly disposed (Fig. 5.3f-h), and reach about 3 cm. Wedge shaped interspaces between these crystals are filled with a mixture of biotite and green amphibole (Fig. 5.3f-h), reaching about 2 cm at places. By weathering, feldspars are set free at their external exposed surfaces, giving the rocks a rough aspect (Fig. 5.3d) at places (Yomeun et al., 2022a; Yomeun, 2023).



Information

Texture and detailed mineralogical composition

Shape, size, abundance (%vol.), arrangement, weathering, inclusion and microstructure of each mineral

Clear pictures with labels and scales

Microscopic description of rocks: An example

Coarse-grained syenites present a granular porphyritic texture dominated by orthoclase crystals. Microcline, plagioclase, and quartz crystals are not present in all samples. These crystals are accompanied by amphibole, biotite, opaque oxide, and accessory minerals as apatite, zircon, and titanite. Clino and orthopyroxenes are also present but uncommon.

Orthoclase

Orthoclase, between 55 and 60%, occurs as rounded to anhedral microcrysts and subhedral to euhedral pheno and megacrysts dispersed haphazardly. Porphyrocrysts exceed 28 mm for the bigger ones; they are strongly converted into microclines (Fig. 5.4a) and/or perthitized (fine lamellae and thick perthites) (Fig. 5.4b) and often show oscillatory zoning at certain places (Fig. 5.4c). The presence of numerous perthites often leads to albitic phases well observed and marked at high magnification by polysynthetic twinning of Albite. Porphyrocrysts are twinned (Carlsbad) (Fig. 5.4a-b), cleaved, and cracked. Sometimes, cleavages and cracks are widened, and along cracks are developed red weathering products (kaolinite), fine unidentified minerals (rubefaction), and at places, fine flakes of muscovite. Porphyrocrysts bear fine biotite flakes, green hornblende, apatite, titanite, zircon, and opaque oxide microcrysts as inclusions (Yomeun, 2023).

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THANK YOU