Deformation textures in a layered BIF sequence

Olinda Gold Pty Ltd

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Characteristics of deformed BIF and interpretations

- The presentation is for people who want to appreciate textures from a deformed BIF sequence, which shows responses of different rock-types to deformation.
- Photos have been taken of dry drill core that has been polished with wet-and-dry sandpaper. There is too much reflection, and the magnetite-rich horizons are too dark, to show detail in wet core, at least for a mediocre photographer like me.
- Magnetite-rich horizons have acted ductilely, accommodating space problems by flowing around dismembered and fractured chert.
- Chert horizons have responded ductilely by boudinage and folding, and brittlely by development of a fracture cleavage.
- Relatively less common chloritic lithologies, that commonly contain mm-scale garnets, have accommodated ductile deformation.
- Chert horizons in relatively less deformed examples show minimal thickness variations. Evidence of chert layers of being comprised of primary discontinuous lenses is less common than deformation-induced attenuation and segmentation. Admittedly, we are only looking at the scale of drill core, and the role of primary variation in layer morphology is considered an important contributor to the final geometries.

Characteristics of deformed BIF and interpretations

- Progressive dismemberment of chert layers has resulted in mixed layered assemblages of chert fragments, ranging in geometry from rounded to angular, within a magnetite matrix. The deformation-induced/modified layering is aligned parallel to lithological layering and has been overprinted by a cleavage, typically at a high angle. As noted above, I am not precluding the formation of layers hosting isolated lenses as being products of primary formation and diagenetic processes.
- Two stages of deformation are inferred. The first stage comprised significant layer-parallel shear, dismemberment of chert horizons, modification of primary isolated chert lenses, ductile flowage of magnetite-rich horizons, and formation of rare folds. Locally, the geometry of thin (mm to sub-mm thickness) magnetite interlayers between chert horizons looks akin to that of stylolites.
- The second deformation stage produced mm- to dm-scale folds that are open to tight, with ductile flow of magnetite-dominated assemblages into fold hinges and along axial planes. The chert horizons responded to the second deformation by folding with common formation of a fracture cleavage that has been infilled by quartz veinlets that commonly form conjugate sets.
- Chert fragments have commonly developed a sub-mm rind of lighter-coloured material that appears to be the same composition as the protolith chert. That is, it does not appear to be an alteration product, but rather a zone of different grain size and/or brittle deformation in response to deformation. I suggest this because the texture is not dissimilar to zones of brittle-ductile deformation that traverse the chert layers. I might also be totally wrong!
- Discontinuous lenses of chert and fragments of chert layers occur in zones that exhibit deformation textures. Relatively larger chert fragments residing in a magnetite matrix, and aligned with layering, commonly have rounded and amoeboid shapes. In addition to modification of primary pre-deformation geometries, this is suggestive of dissolution accompanying the deformation process during the first event. This is inference on my part, and, if correct, makes me wonder where the silica went. In the second deformation, the sink for the silica can be rationalised as contributing to the quartz veinlets that infill the fracture cleavage.

Characteristics of deformed BIF and interpretations

- There is a crude ordering to the photos, with the first half showing progressive fold development. The remainder show various deformation textures, including boudinage, dismemberment of chert horizons, and clast-in-matrix textures. I have added rudimentary labels to the figures.
- My questions to my learned colleagues, particularly those who have experience in deformed BIF sequences, are:

➢ How much of the discontinuous nature of the chert layers can be attributed to primary geometry/morphology, reflecting primary diagenetic features? I think it is locally, but not overwhelmingly, significant. I also know this can be hard to tell in some cases due to the two, variably intense overprinting deformations.

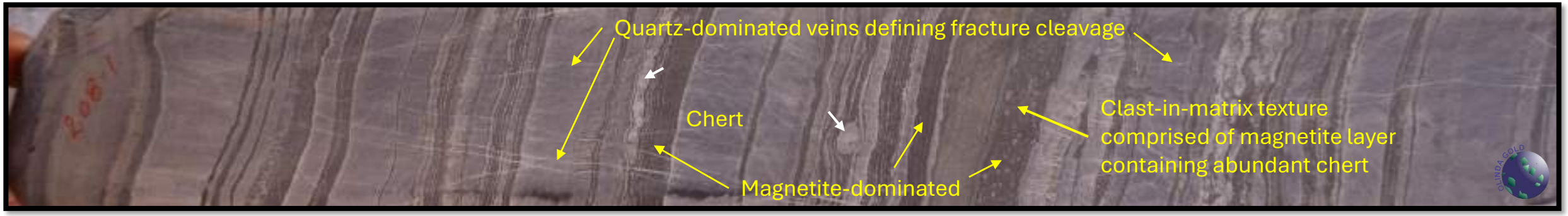
➢ Are there any decent papers out there looking at the ductile behaviour of magnetite in BIF sequences? I couldn't find any. Most stuff deals with slip systems within the crystallographic framework of individual magnetite crystals.

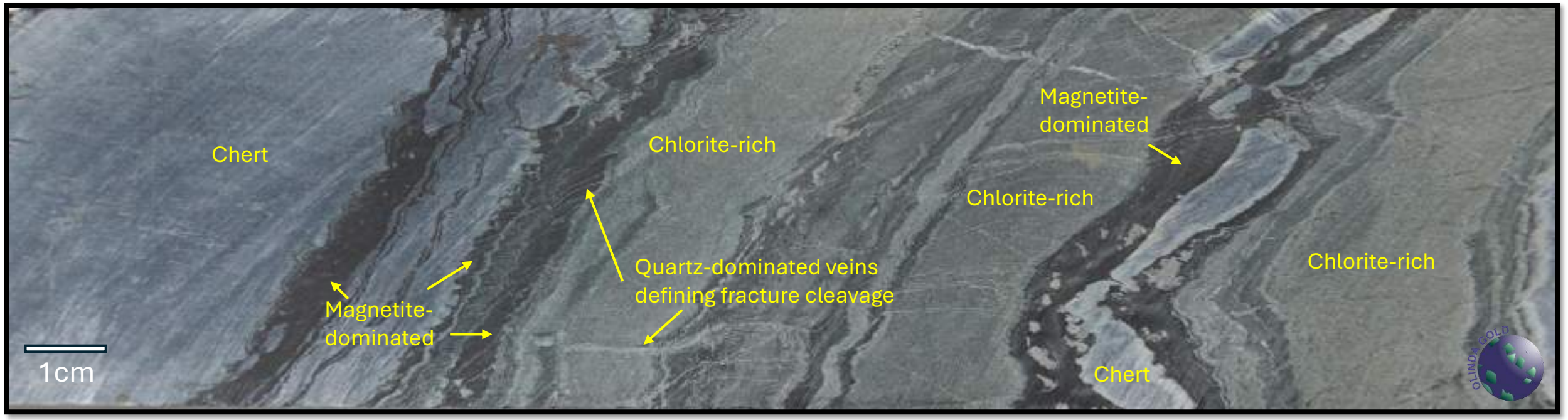
➢ Is my supposition of silica dissolution and removal viable, or are there reactive processes at work that I am unaware of? I'm not ruling out reactions between iron- and silica-rich horizons early in sequence evolution e.g. pre-induration when there was still significant intergranular fluid.

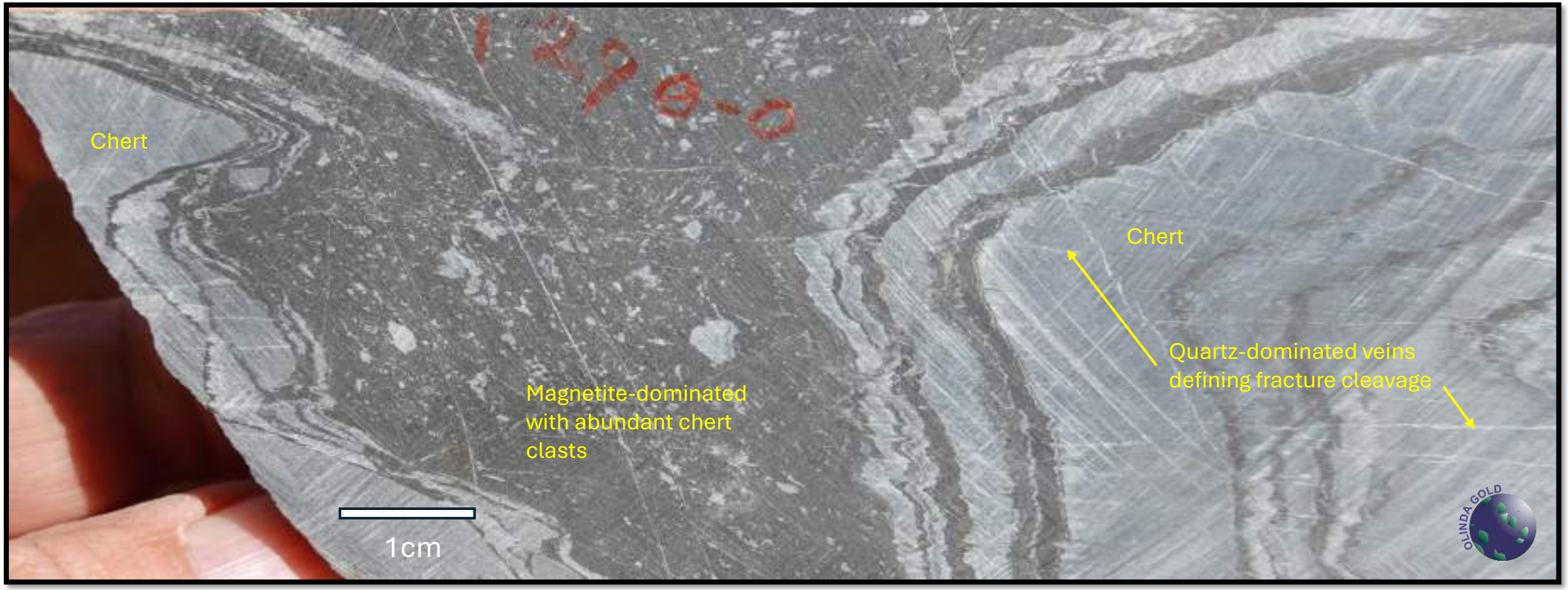
➢ Has anyone seen examples of magnetite stylolites?

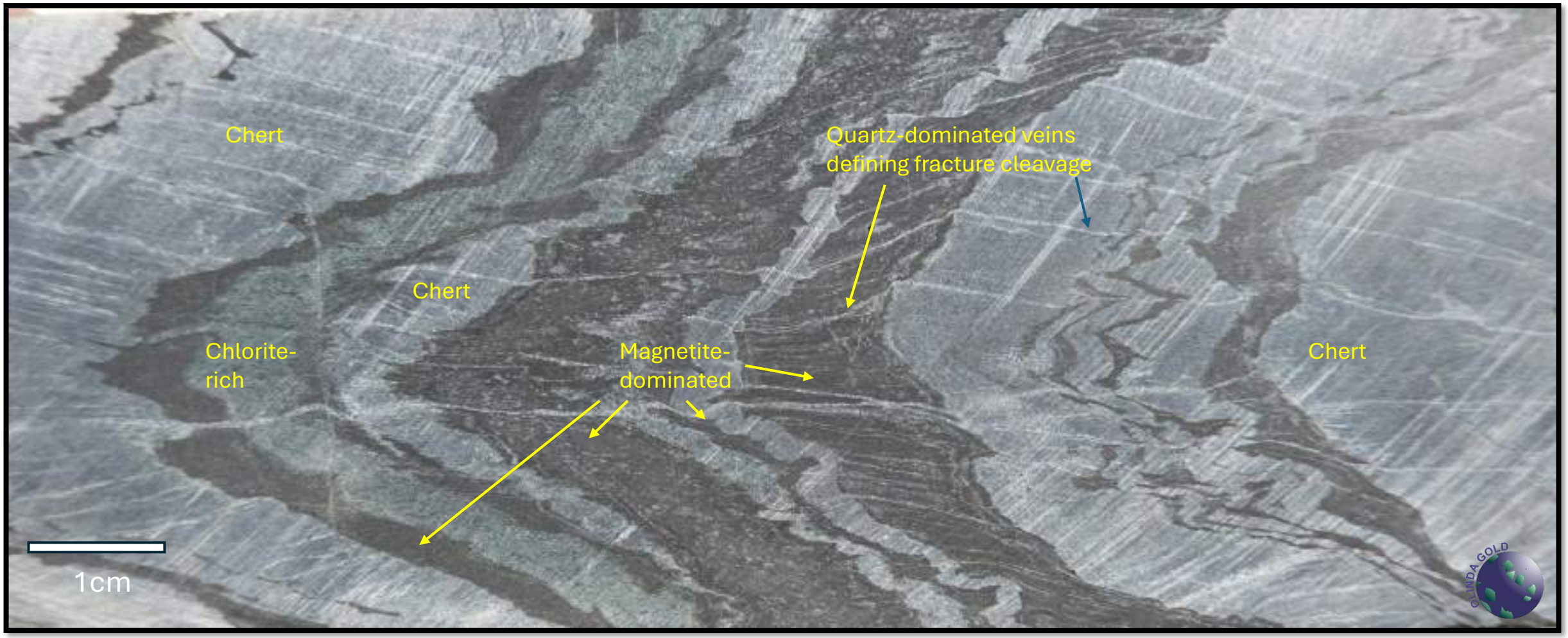
Relatively undeformed BIF (compared to that in the subsequent slides)

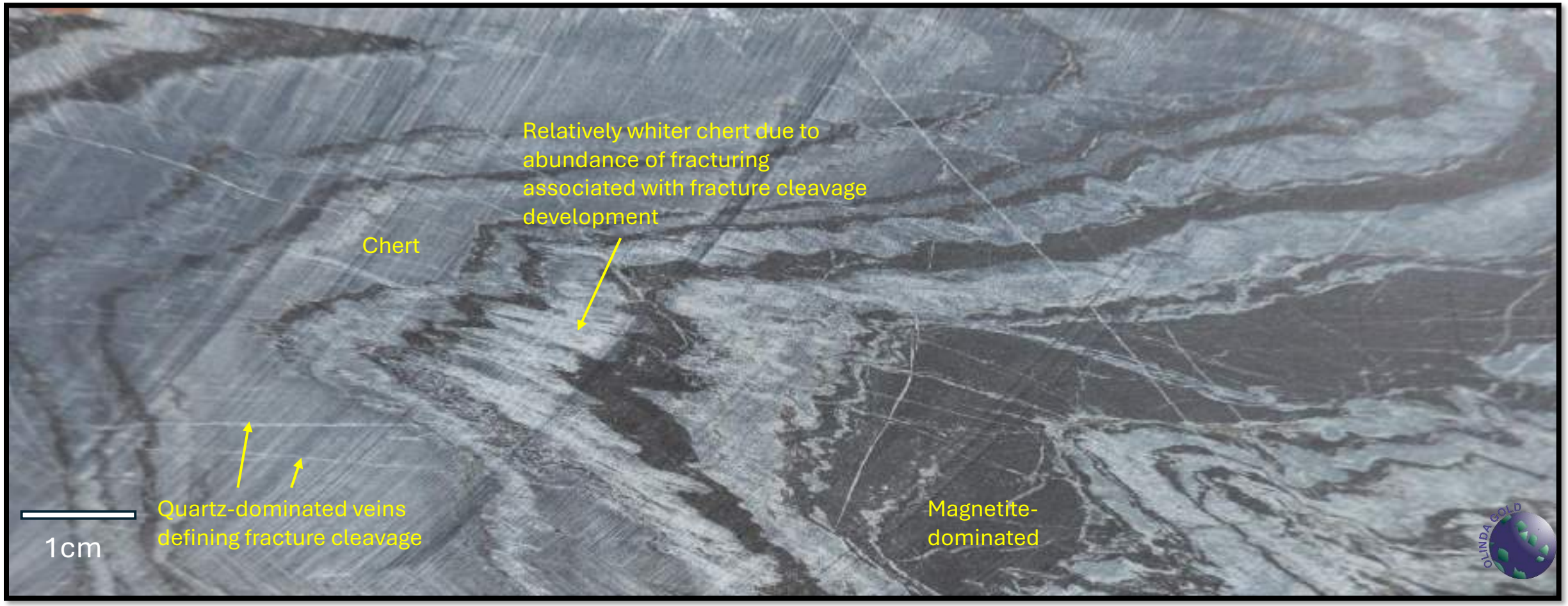
- The photo here shows the general expression of the relatively less deformed BIF sequences comprising dark layers of magnetite-rich material interlayered with grey chert material.
- The magnetite and chert horizons are relatively planar and have consistent layer thicknesses, with only minor variation due to deformation-induced layer-parallel attenuation and fracturing.
- However, there are local isolated lenses and layers (white arrows), suggesting the geometry of chert lithologies in the following slides is in part a product of primary morphology.
- Note that a fracture cleavage is developed at a low angle to the core axis and is visually obvious due to infill by quartz.
- Best development of the fracture cleavage occurs in the rheologically more competent chert horizons. The following slides show progressive development of fold geometries as the relatively planar sequence is deformed.

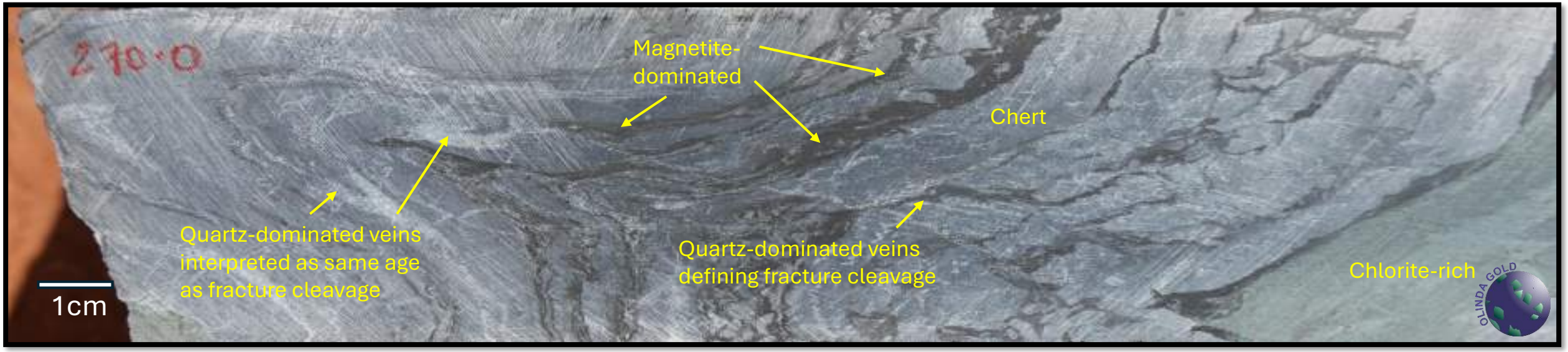


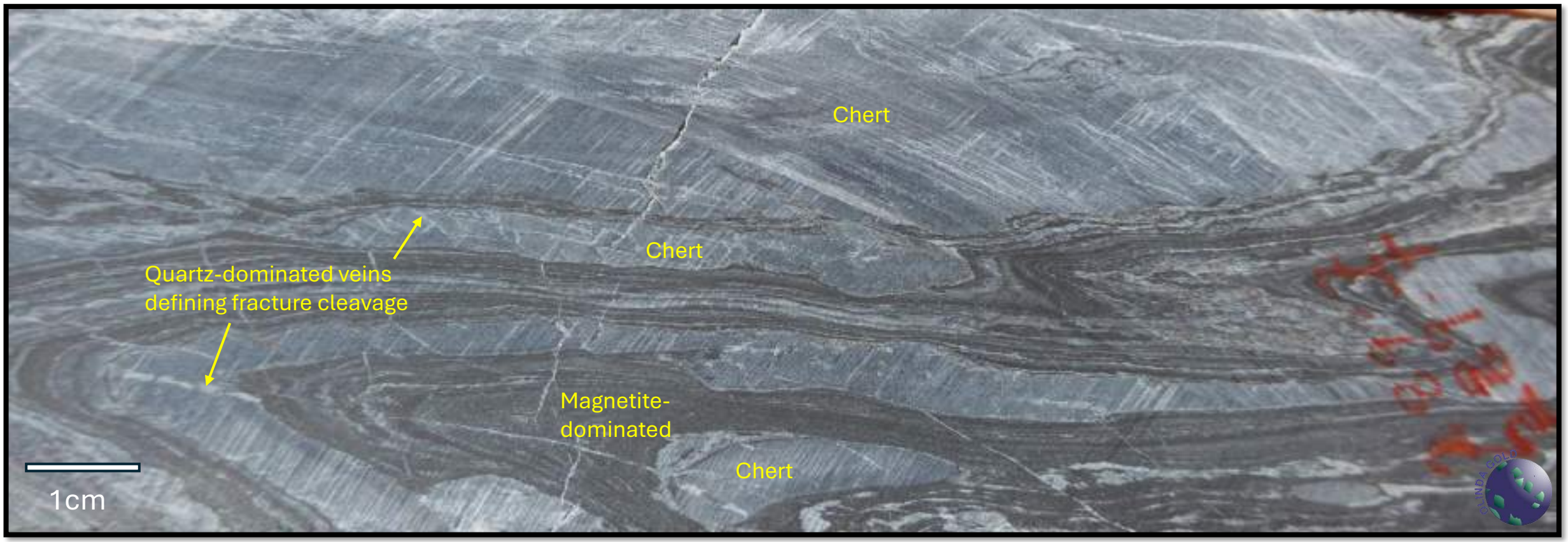

Chert
Chlorite-rich
Magnetite-dominated
Chlorite-rich
Chlorite-rich
Magnetite-dominated
Quartz-dominated veins defining fracture cleavage
1cm
Chert
OLINDA GOLD

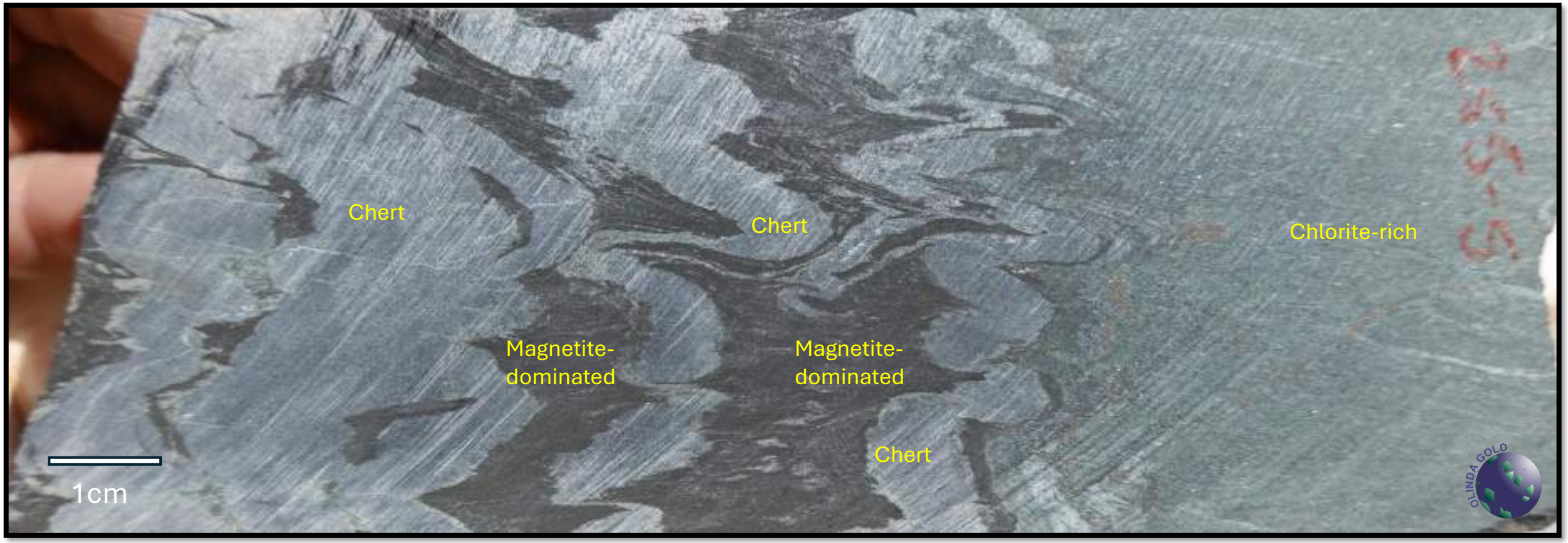

Chert
Chert
Quartz-dominated veins
defining fracture cleavage
Magnetite-dominated
with abundant chert
clasts
1cm

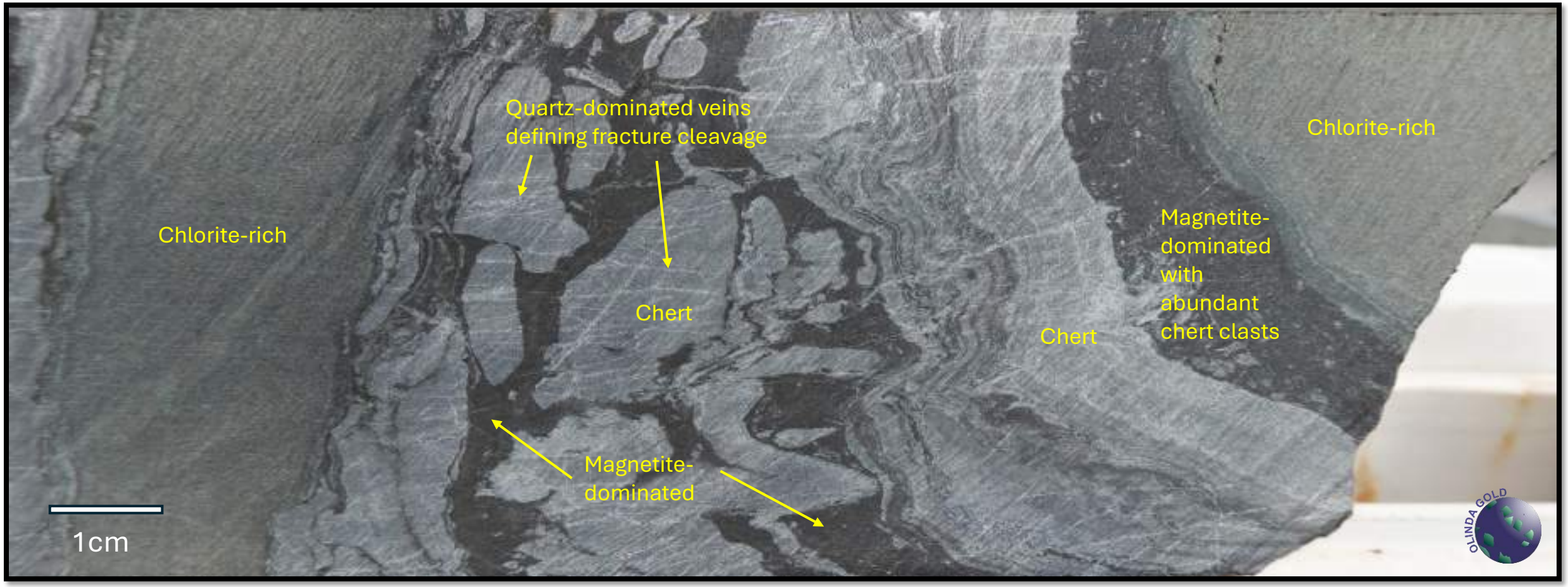

Chert
Quartz-dominated veins
defining fracture cleavage
Chert
Chlorite-
rich
Magnetite-
dominated
Chert
1cm


Relatively whiter chert due to abundance of fracturing associated with fracture cleavage development
Chert
Quartz-dominated veins defining fracture cleavage
1cm
Magnetite-dominated

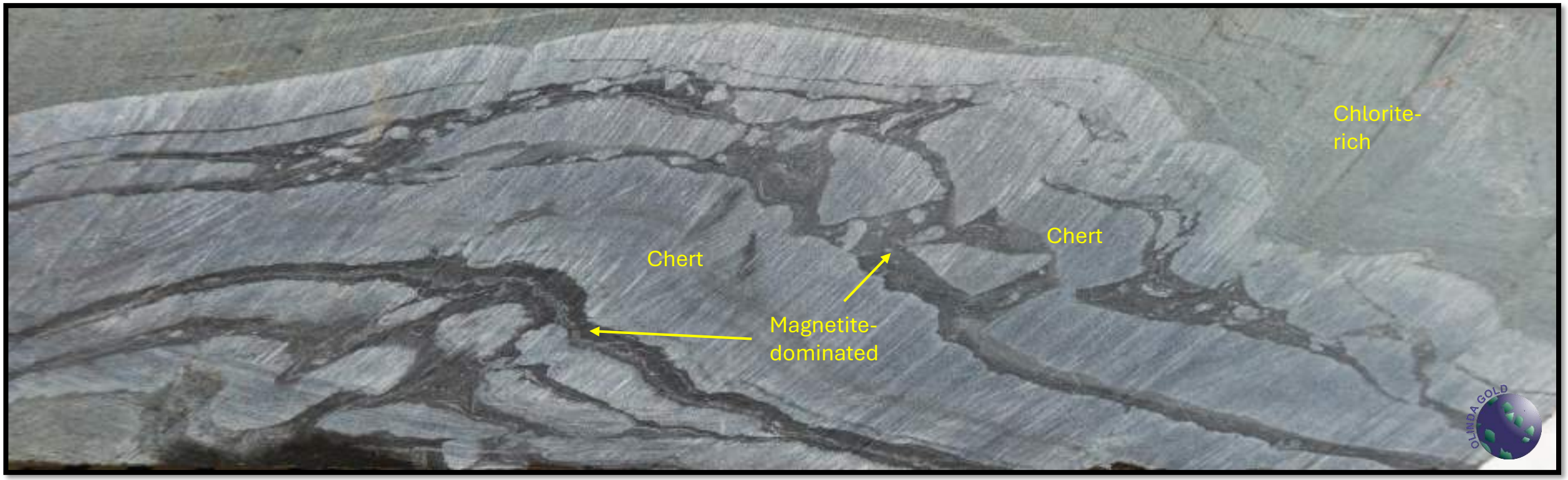

270·0
Magnetite-dominated
Chert
Quartz-dominated veins interpreted as same age as fracture cleavage
Quartz-dominated veins defining fracture cleavage
Chlorite-rich
1cm
OLINDA GOLD

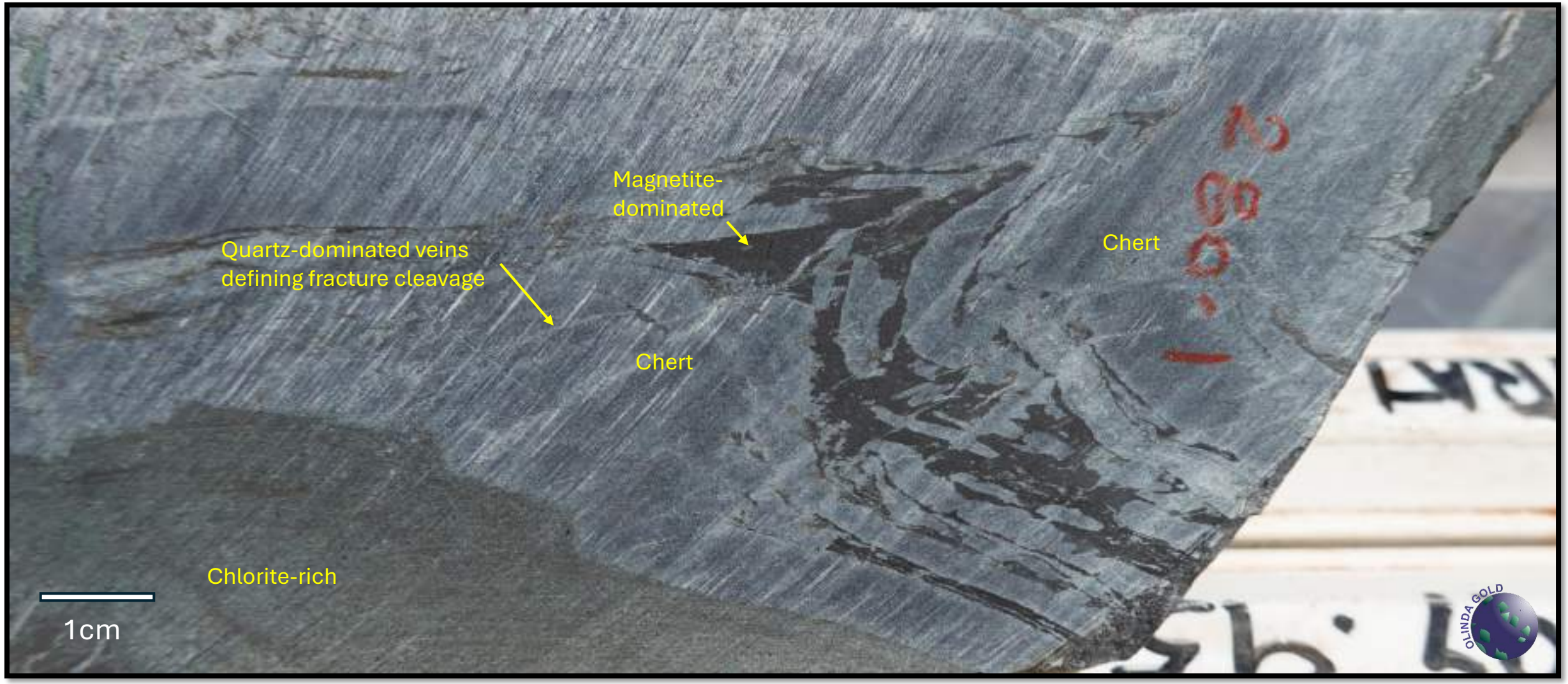

Chert
Chert
Quartz-dominated veins
defining fracture cleavage
Magnetite-
dominated
Chert
1cm

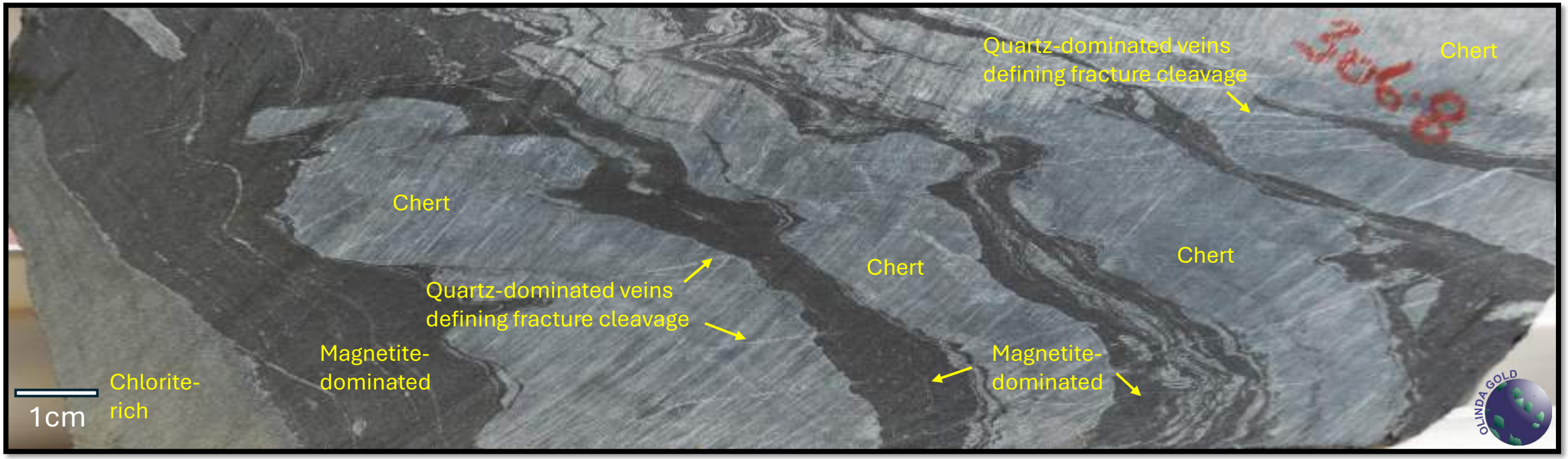

Chert
Chert
Chlorite-rich
Magnetite-dominated
Magnetite-dominated
Chert
1cm
OLINDA GOLD

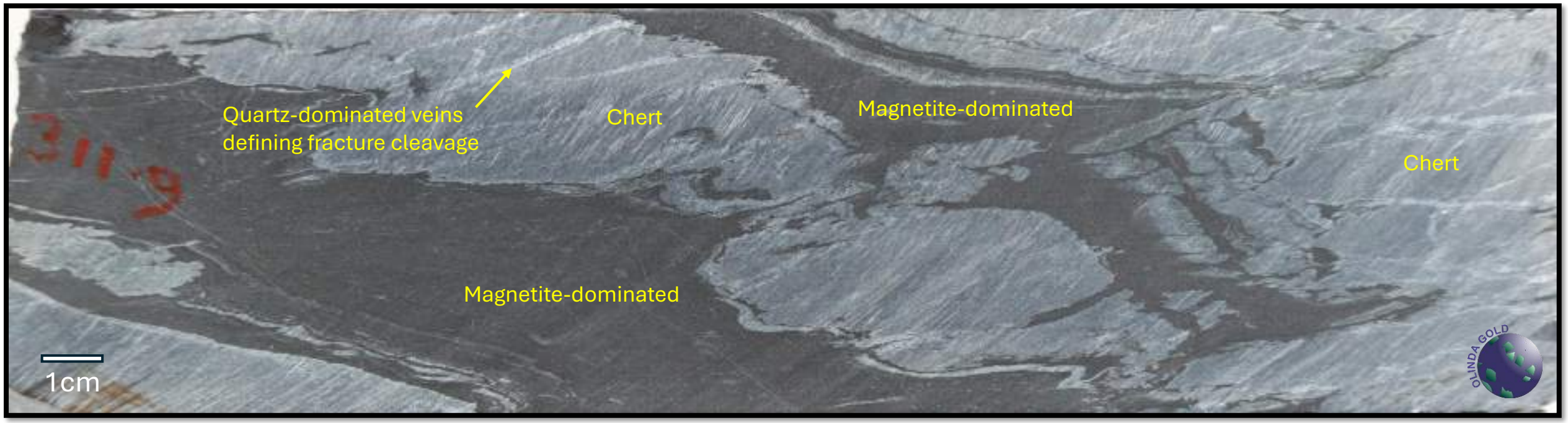

Quartz-dominated veins defining fracture cleavage
Chlorite-rich
Chlorite-rich
Chert
Chert
Magnetite-dominated with abundant chert clasts
Magnetite-dominated
1cm
OLINDA GOLD

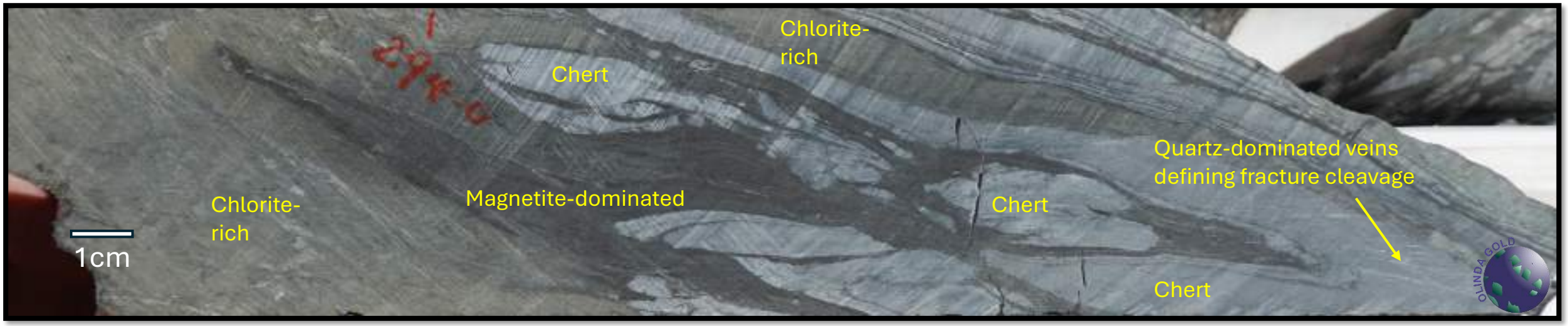

Chlorite-rich
Chert
1cm
Chlorite-rich
Chert
Detail in next photo


Chlorite-
rich
Chert
Chert
Magnetite-
dominated

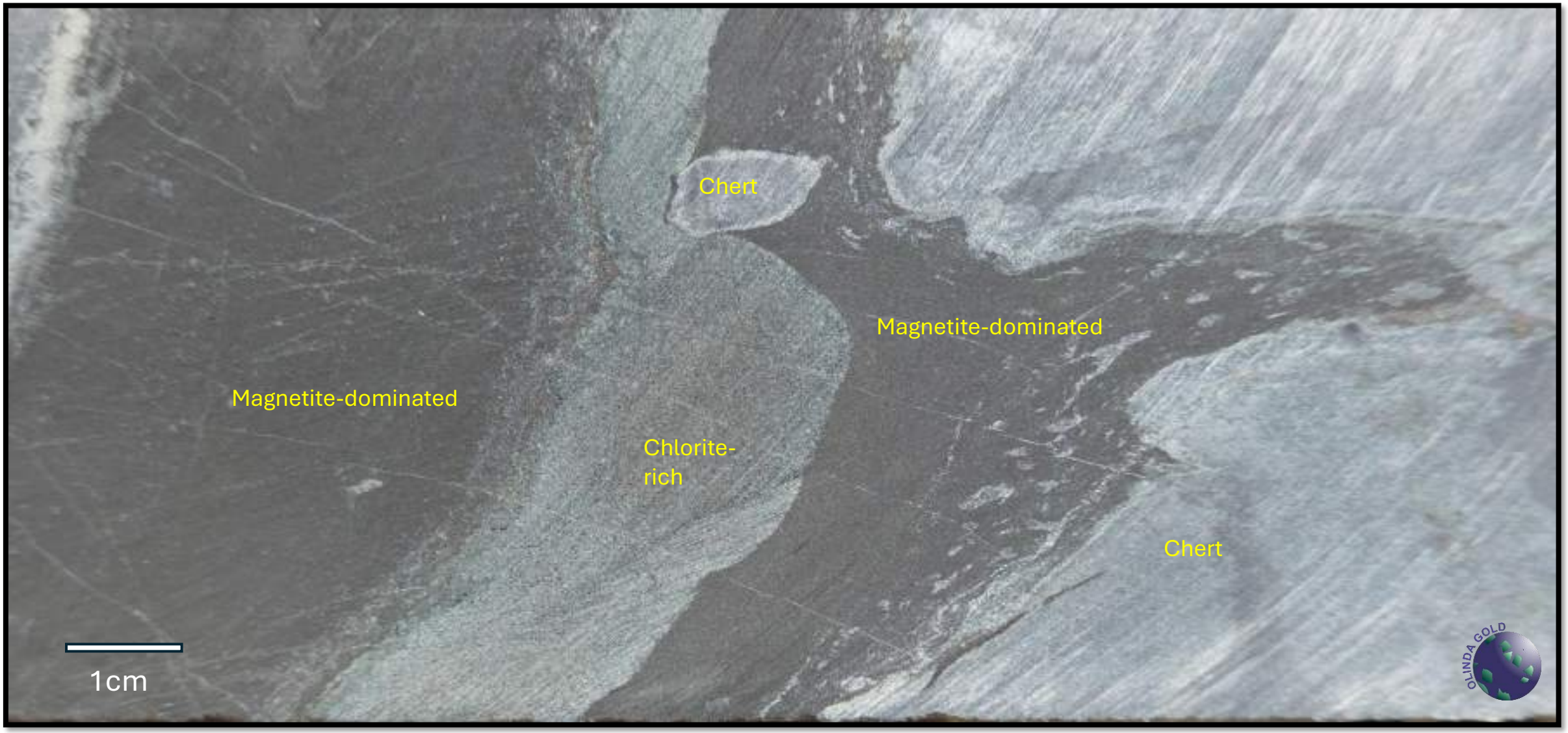

Magnetite-
dominated
Quartz-dominated veins
defining fracture cleavage
Chert
Chert
Chlorite-rich
1cm

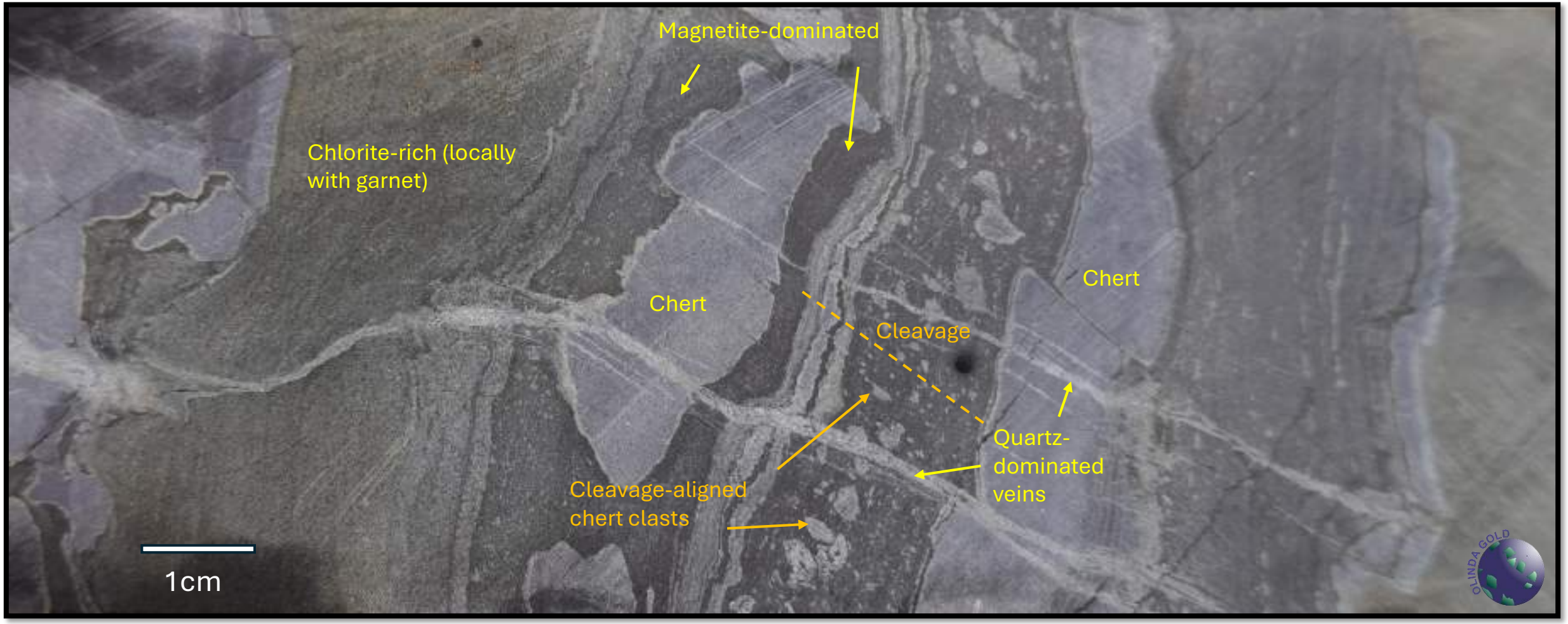

Quartz-dominated veins
defining fracture cleavage
Chert
Chert
Quartz-dominated veins
defining fracture cleavage
Chert
Chert
Magnetite-
dominated
Magnetite-
dominated
Chlorite-
rich
1cm
OLINDA GOLD


Quartz-dominated veins
defining fracture cleavage
Chert
Magnetite-dominated
Chert
Magnetite-dominated
1cm
OLINDA GOLD

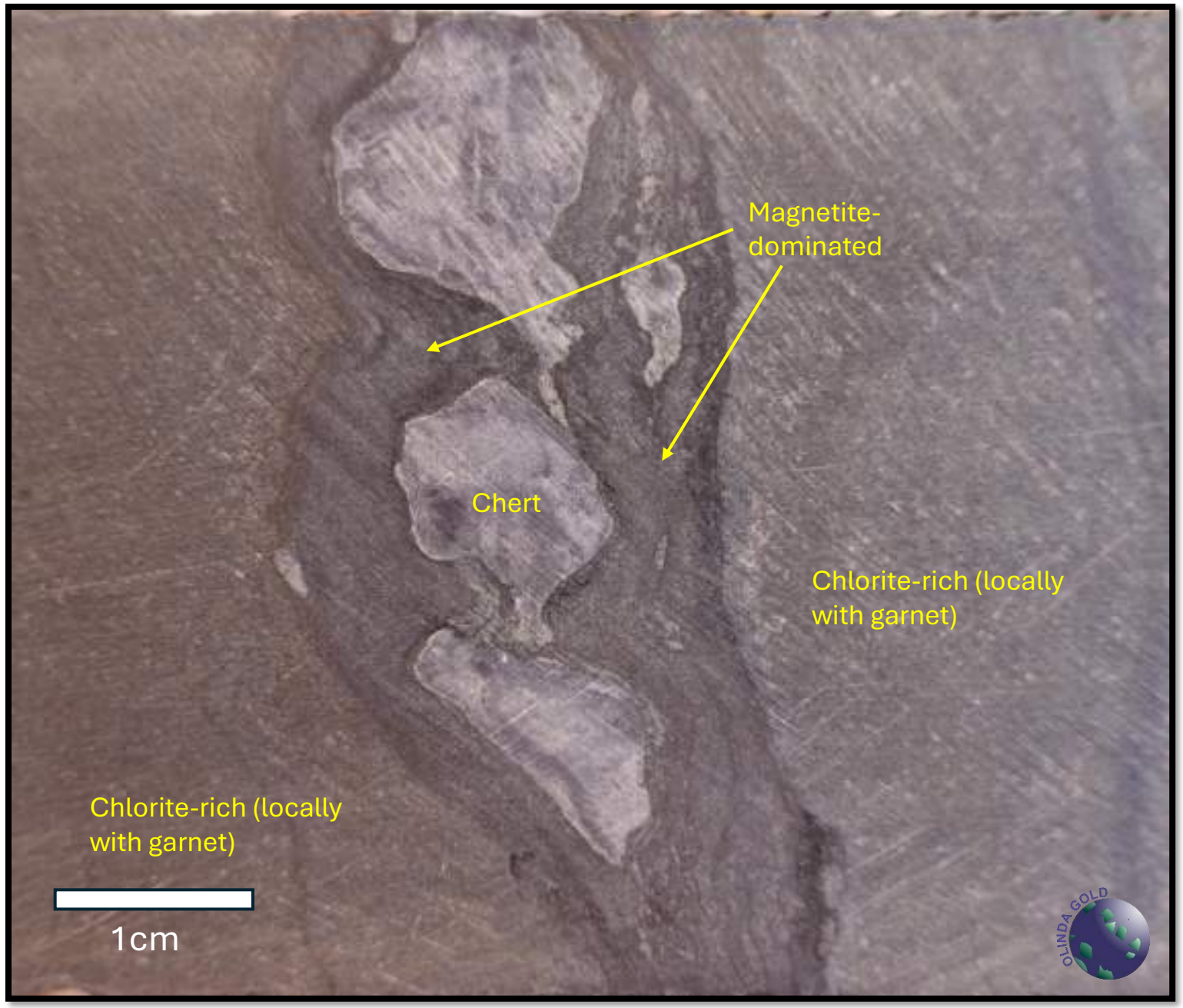

Chlorite-
rich
Chert
Chlorite-
rich
Magnetite-dominated
Chert
Quartz-dominated veins
defining fracture cleavage
Chert
1cm
OLINDA GOLD


Chert
Magnetite-dominated
Chlorite-rich
Detail in next photo
Chert
1cm
OLINDA GOLD

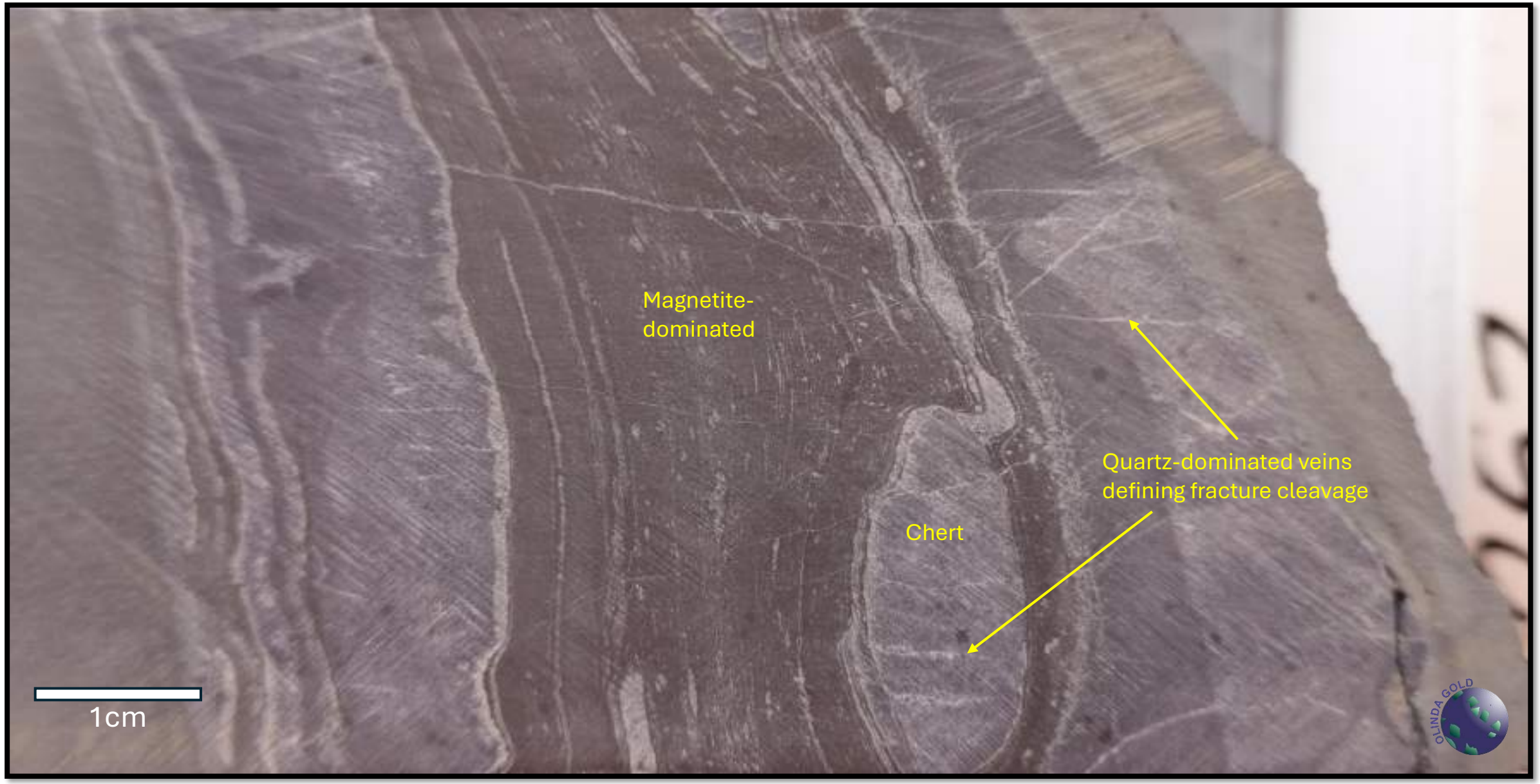

Chert
Magnetite-dominated
Magnetite-dominated
Chlorite-
rich
Chert
1cm
OLINDA GOLD

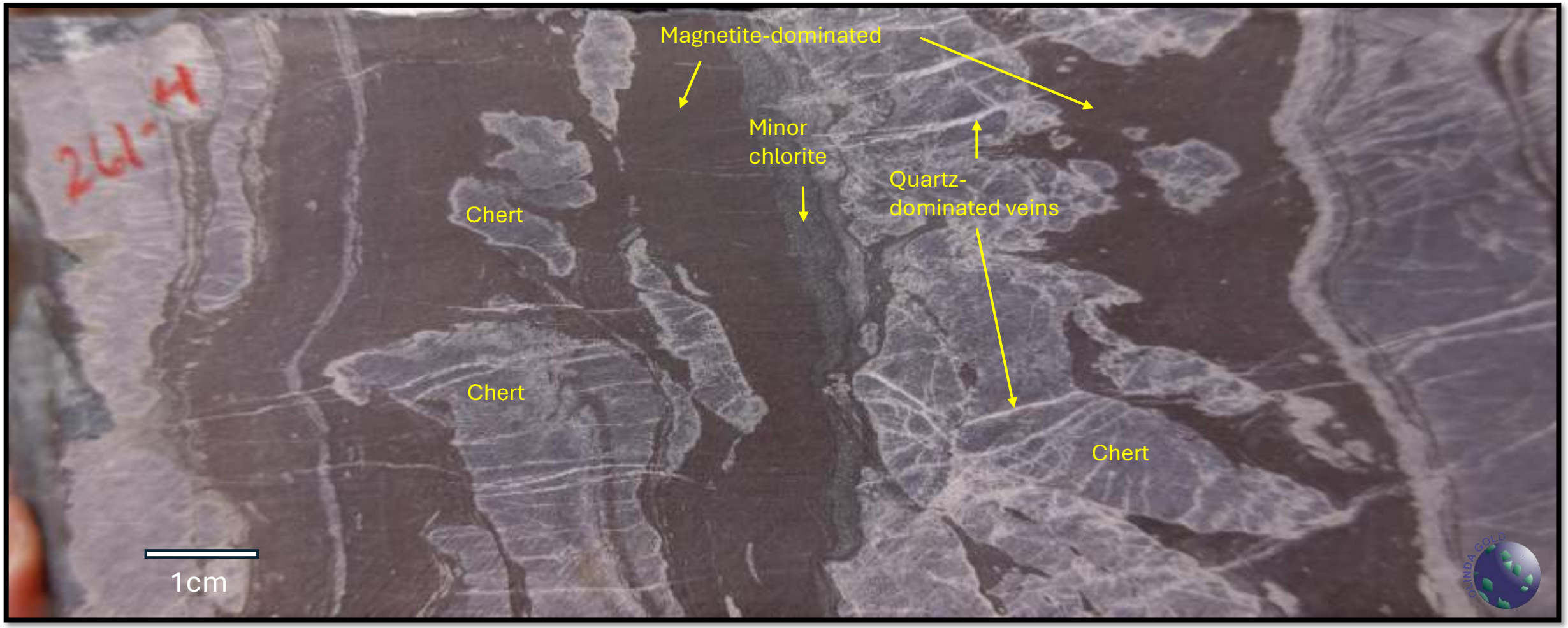

Magnetite-dominated
Chlorite-rich (locally with garnet)
Chert
Chert
Cleavage
Quartz-dominated veins
Cleavage-aligned chert clasts
1cm

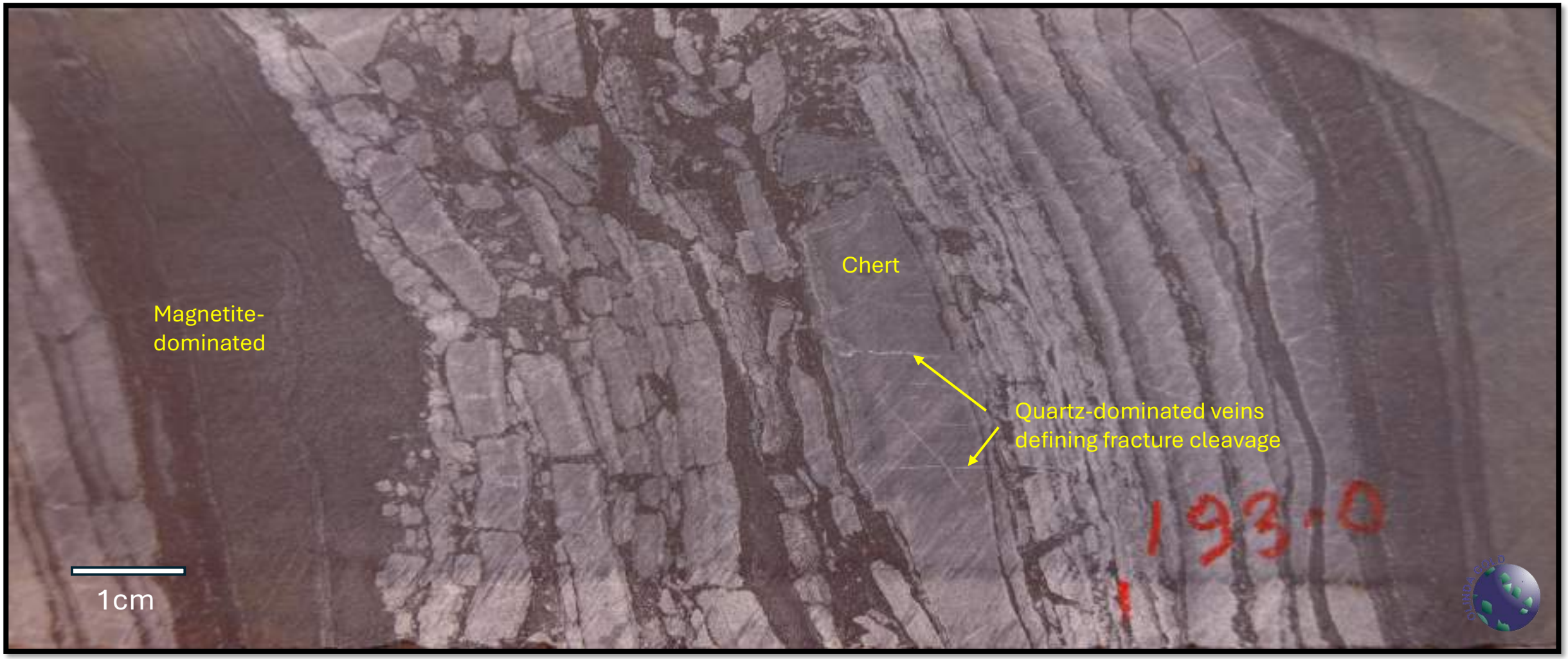
Modification of original discontinuous and/or lensoidal chert horizons?

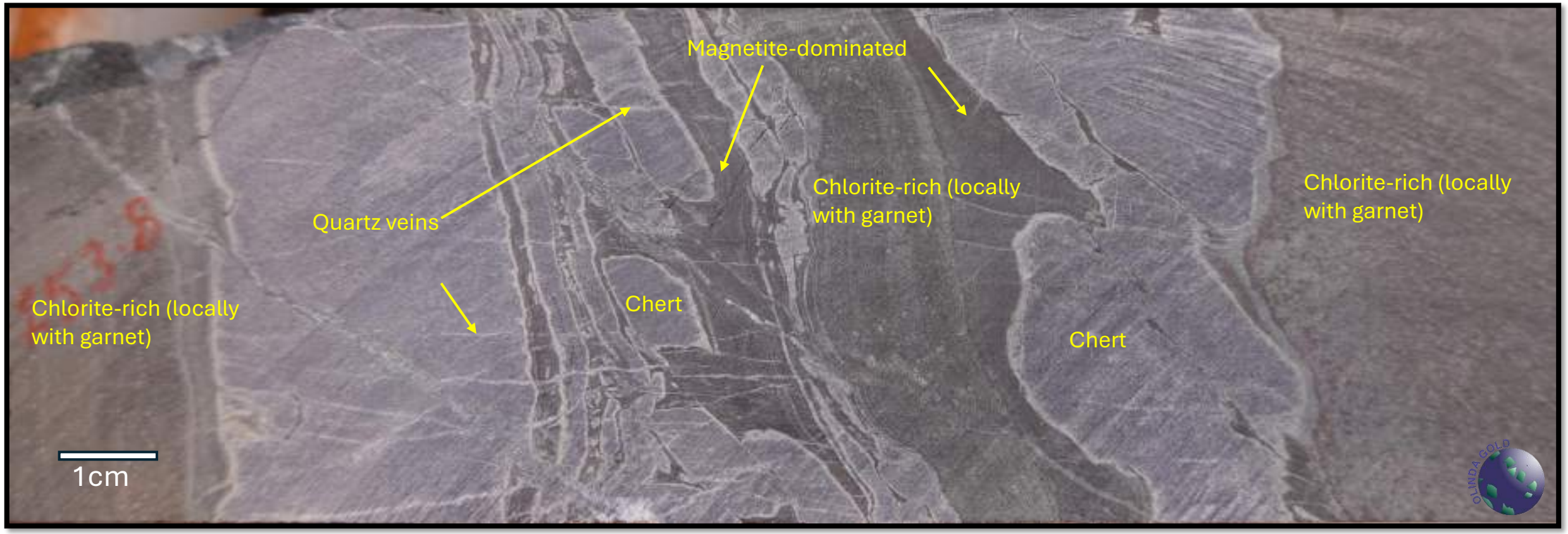


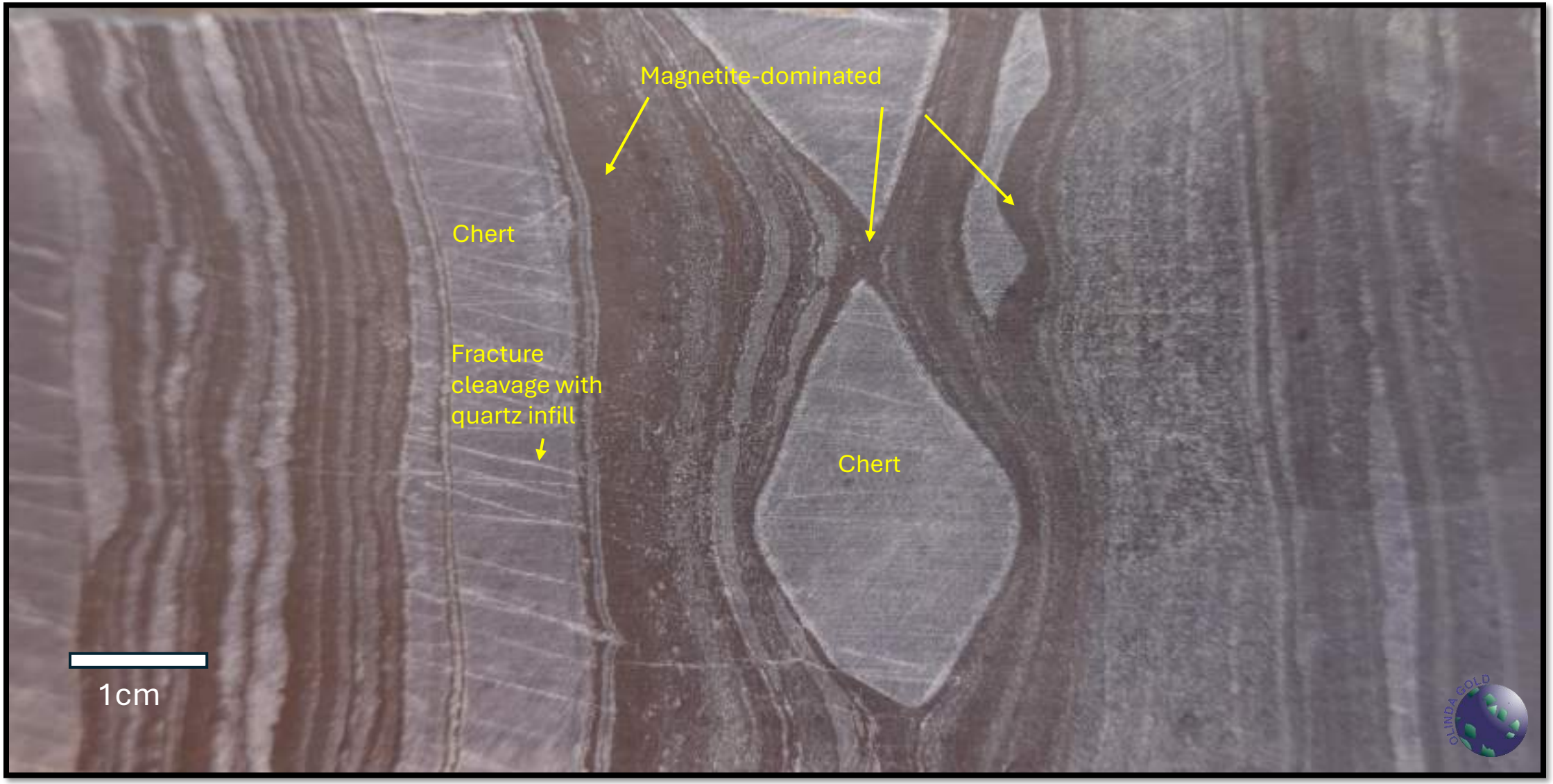
Modification of original discontinuous and/or lensoidal chert horizons?

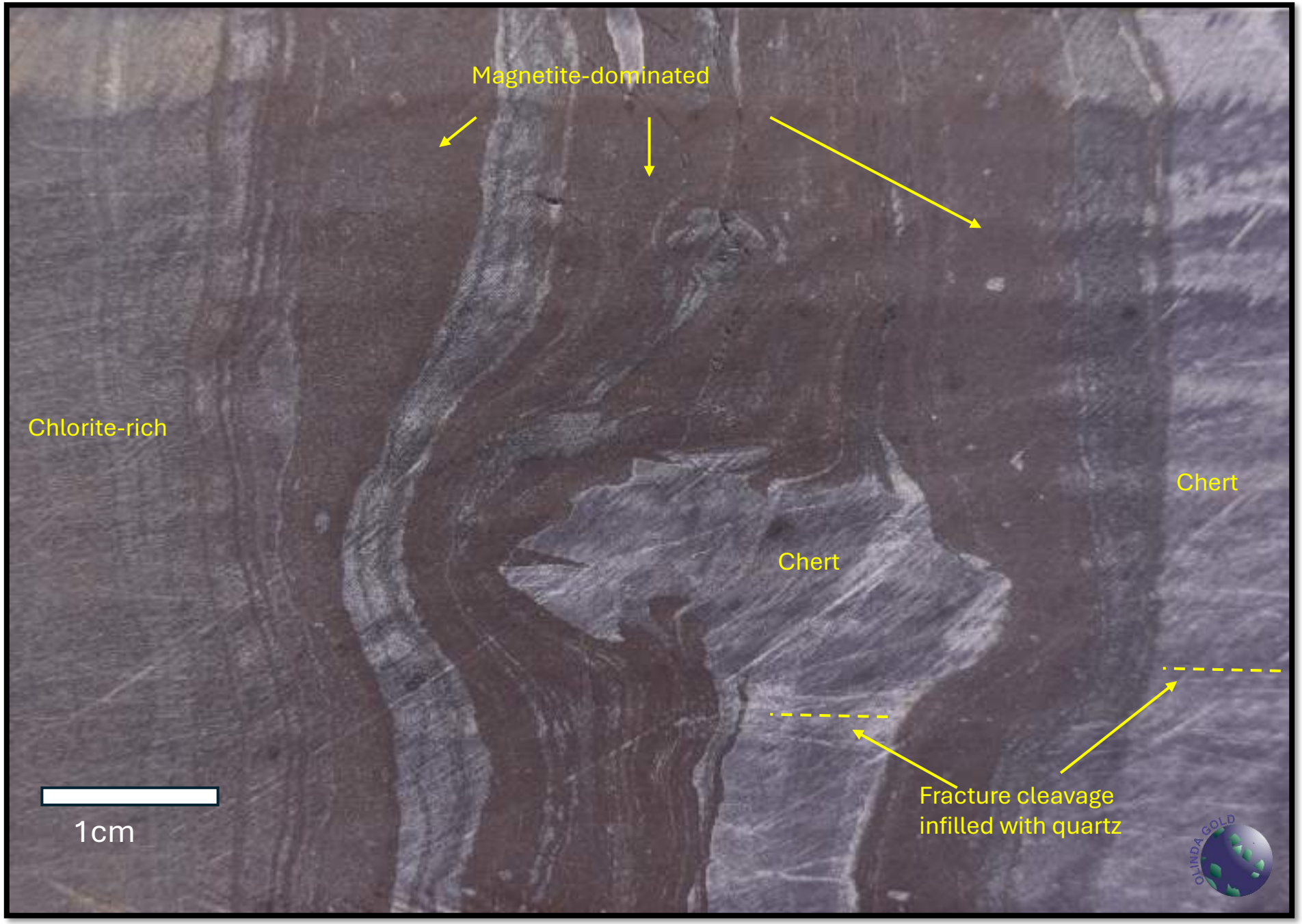


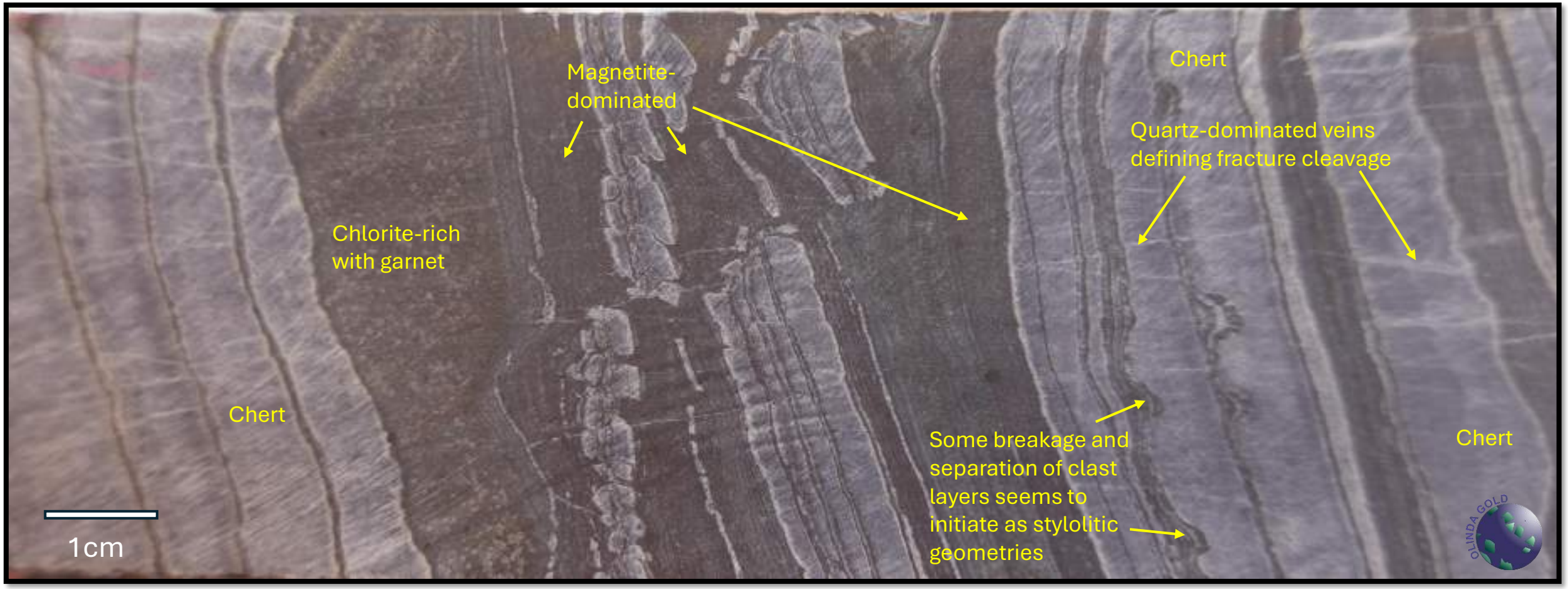

Magnetite-dominated
Minor chlorite
Quartz-dominated veins
Chert
Chert
Chert
1cm

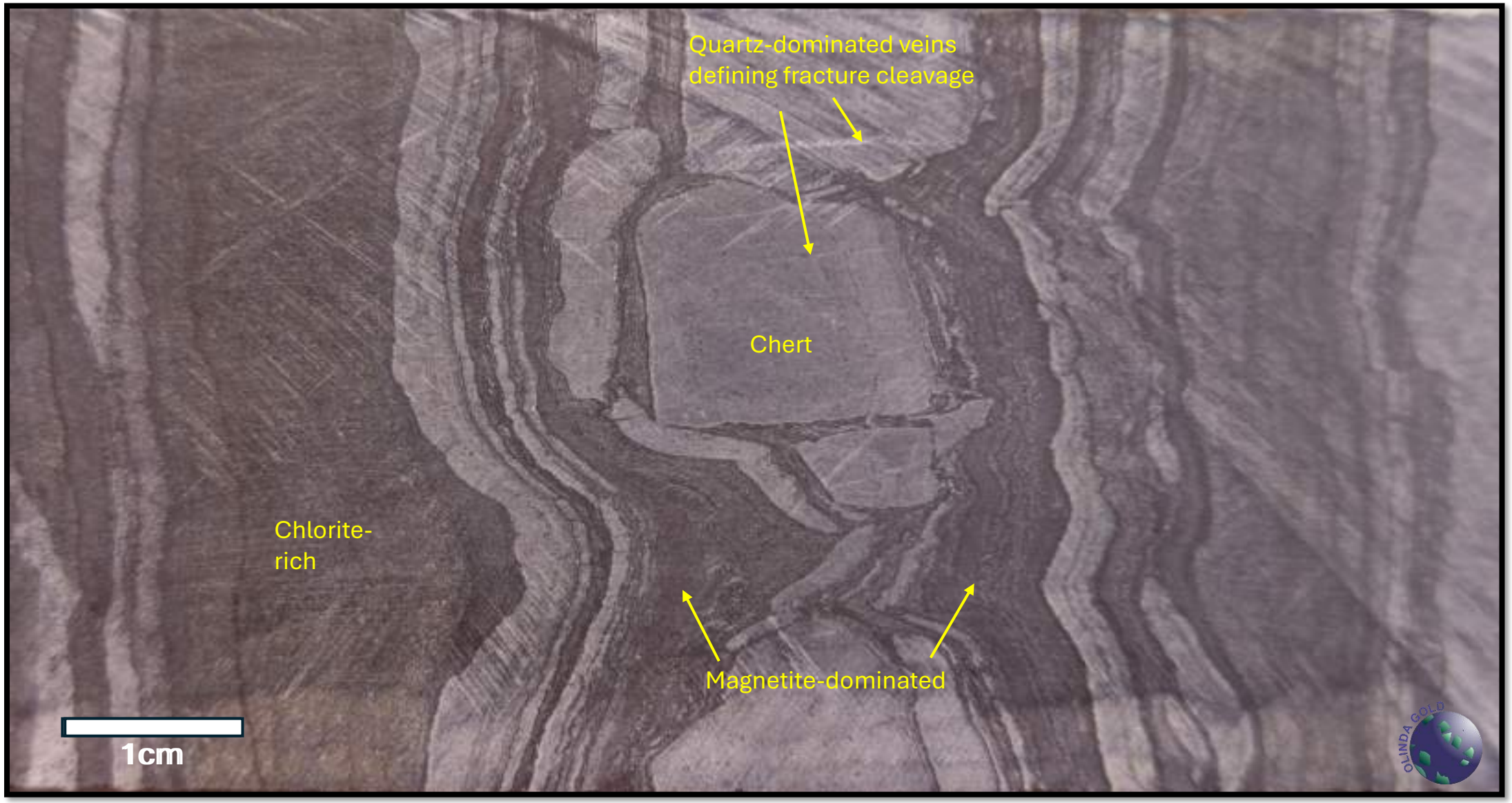

Magnetite-dominated
Chert
Quartz-dominated veins defining fracture cleavage
193.0
1cm

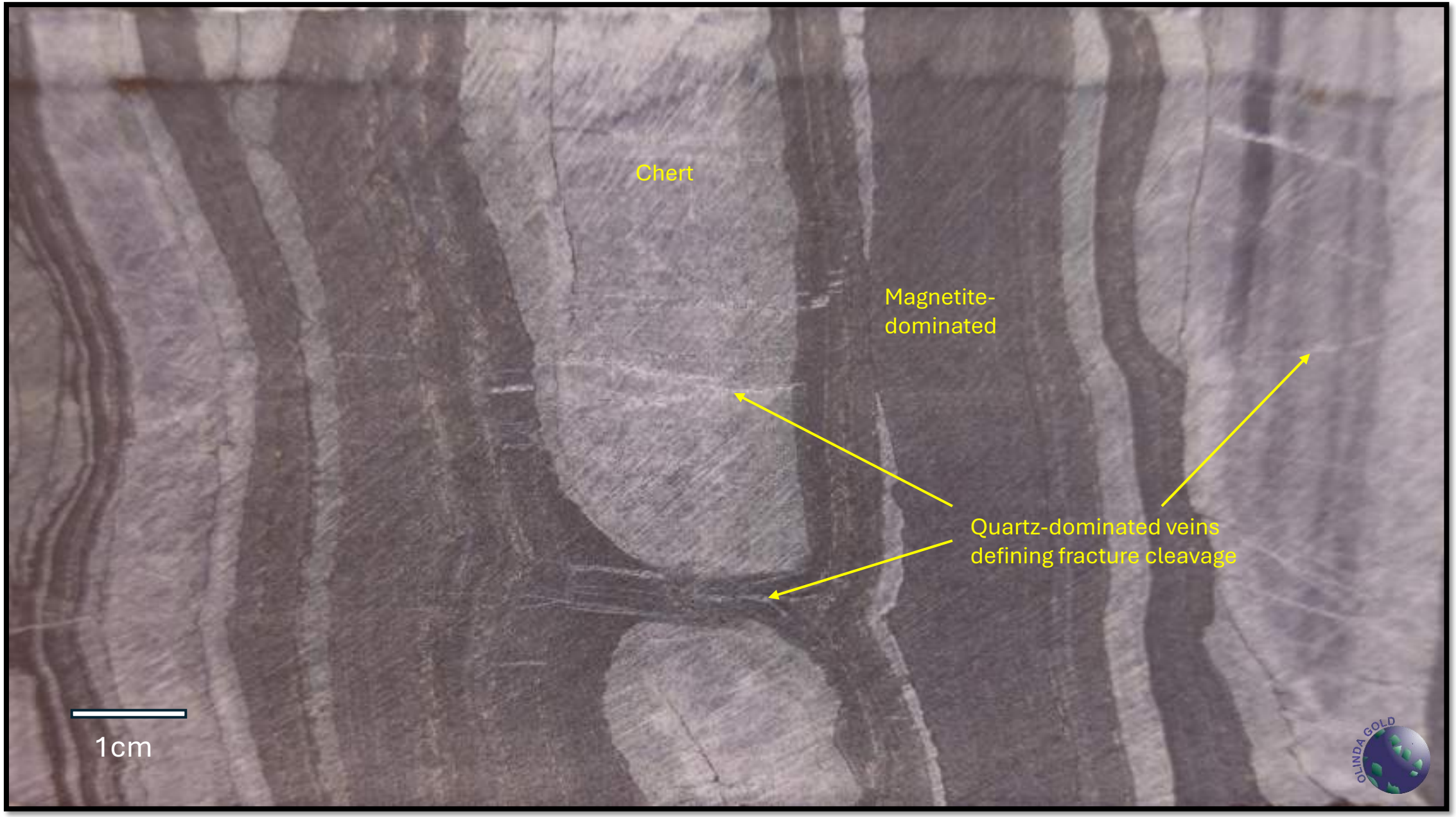

Magnetite-dominated
Quartz veins
Chlorite-rich (locally with garnet)
Chlorite-rich (locally with garnet)
Chlorite-rich (locally with garnet)
Chert
Chert
1cm

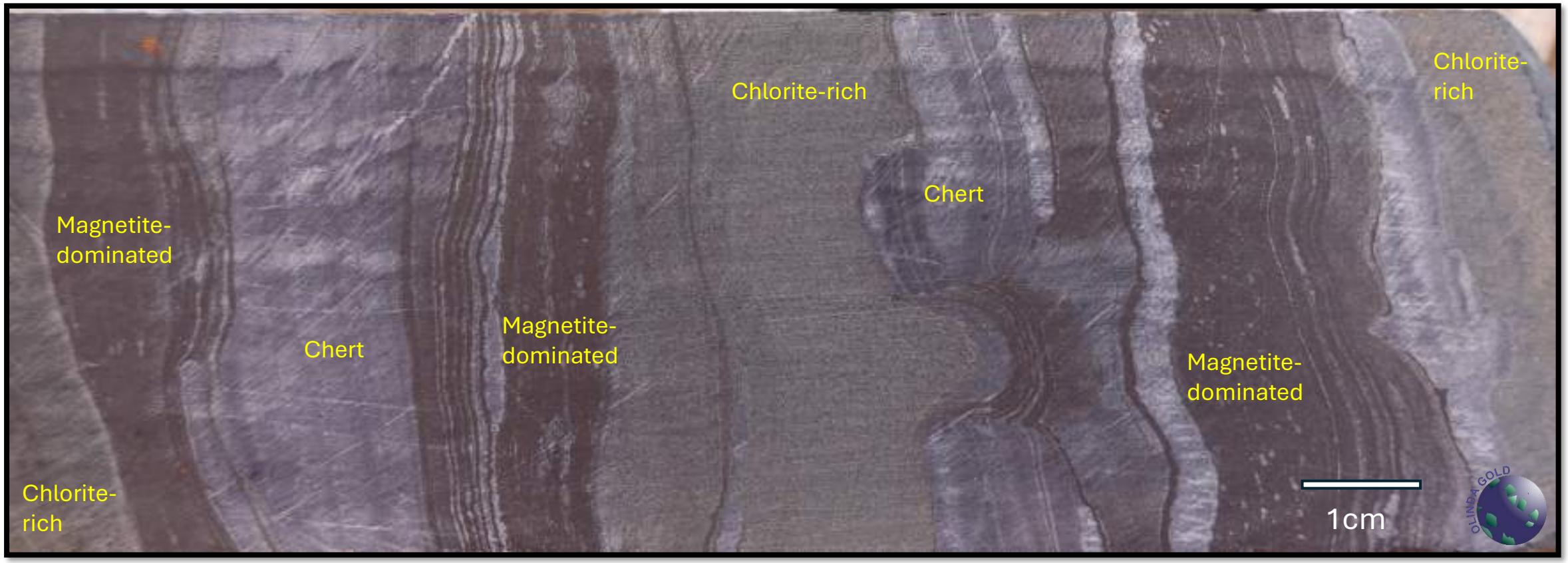

Magnetite-dominated
Chert
Fracture cleavage with quartz infill
Chert
1cm

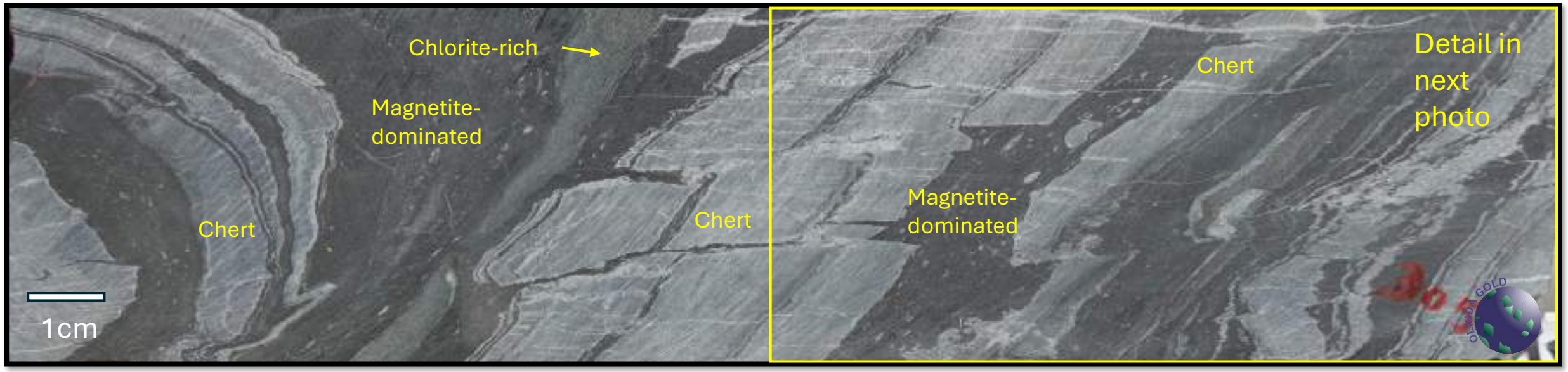

Magnetite-dominated
Chlorite-rich
Chert
Chert
1cm
Fracture cleavage
infilled with quartz

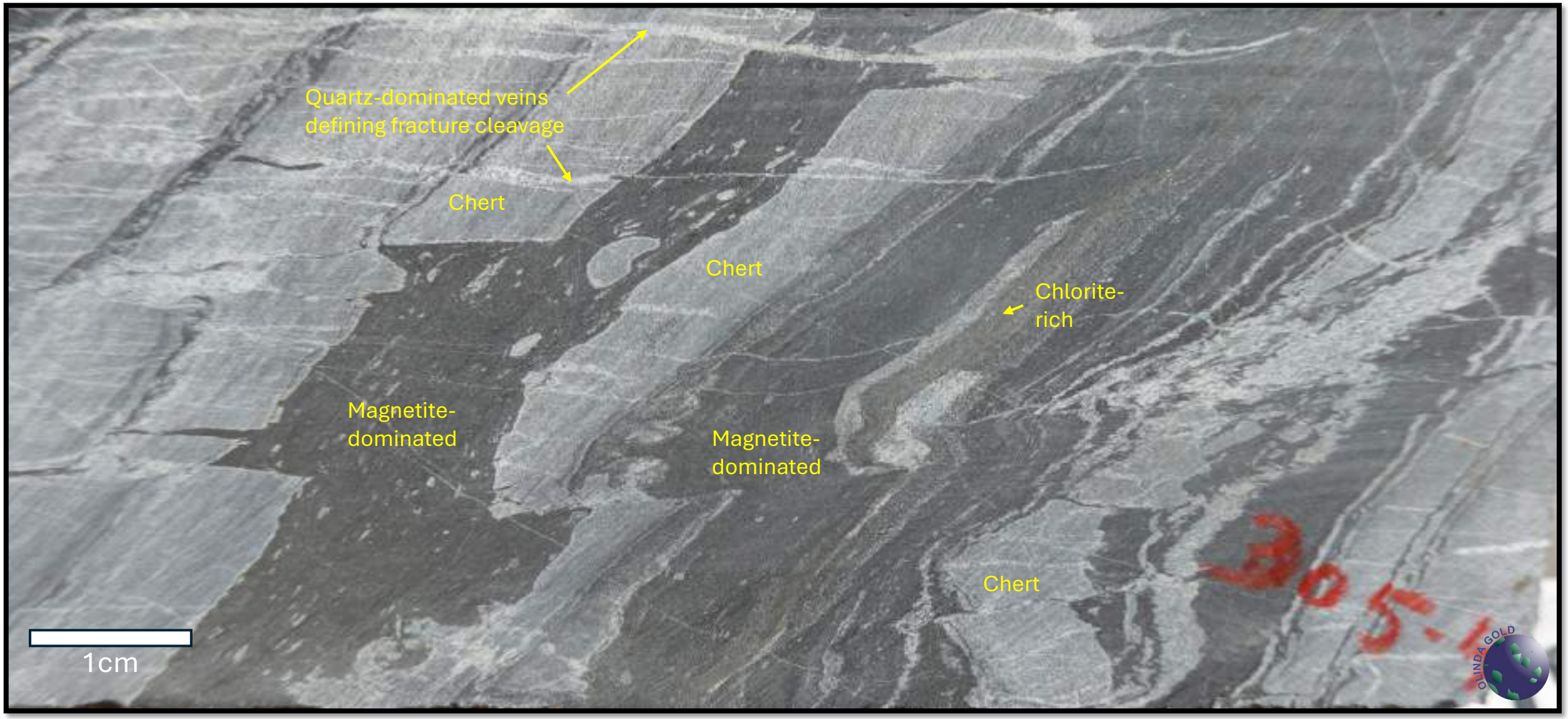

Magnetite-dominated
Chert
Quartz-dominated veins defining fracture cleavage
Chlorite-rich with garnet
Chert
Some breakage and separation of clast layers seems to initiate as stylolitic geometries
Chert
1cm

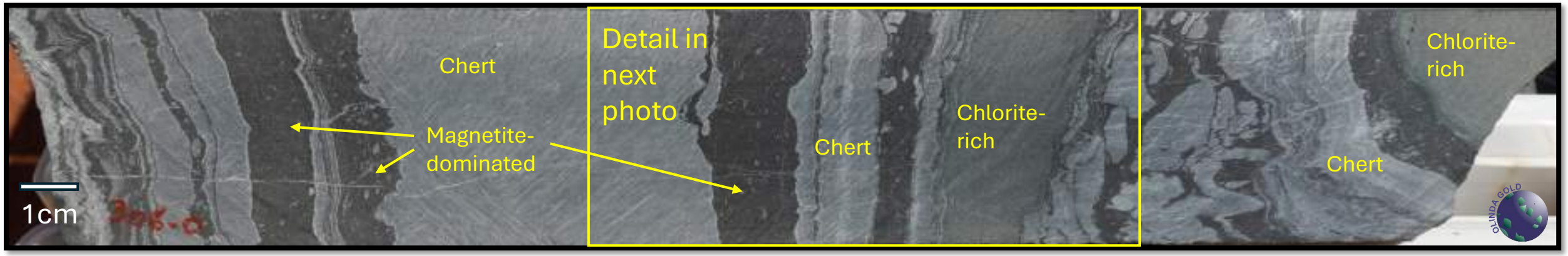

Quartz-dominated veins
defining fracture cleavage
Chert
Chlorite-
rich
Magnetite-dominated
1cm

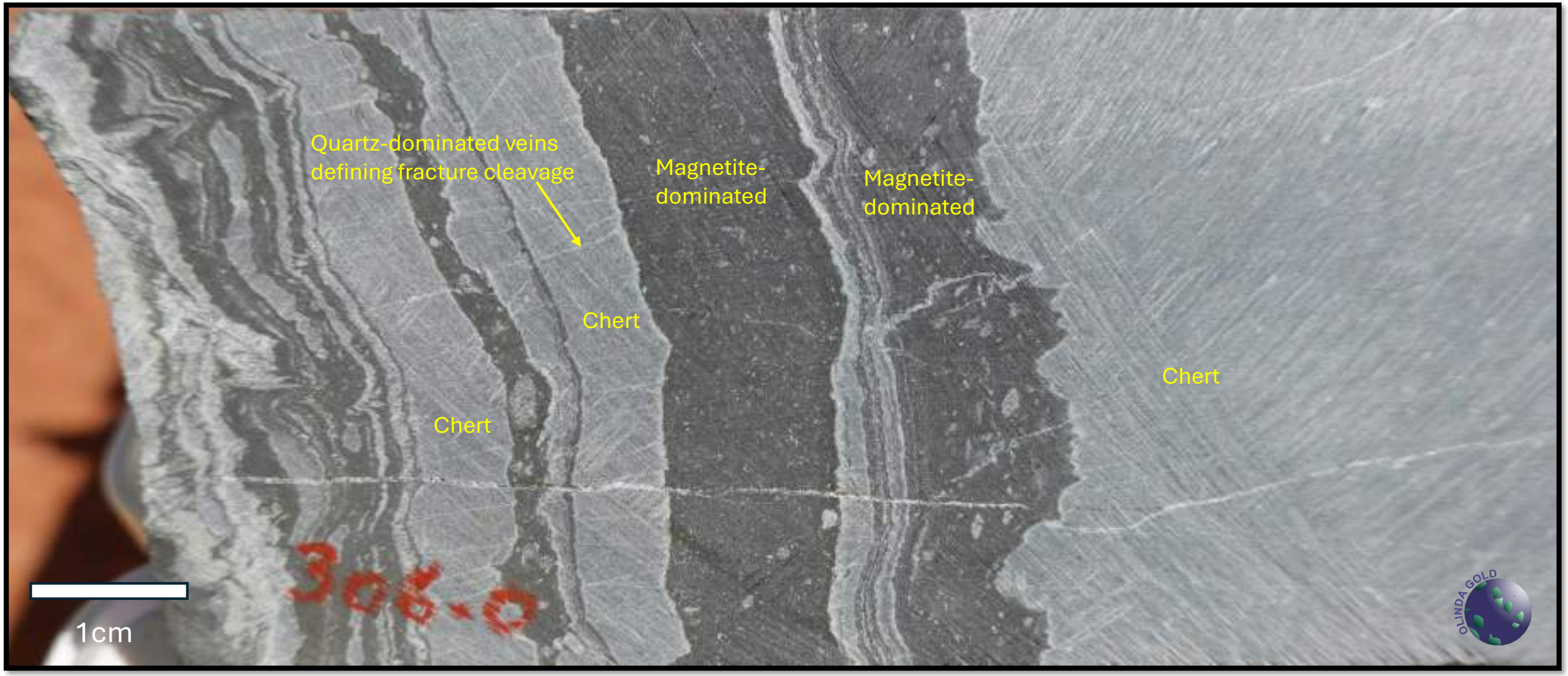

Chert
Magnetite-dominated
Quartz-dominated veins defining fracture cleavage
1cm
OLINDA GOLD

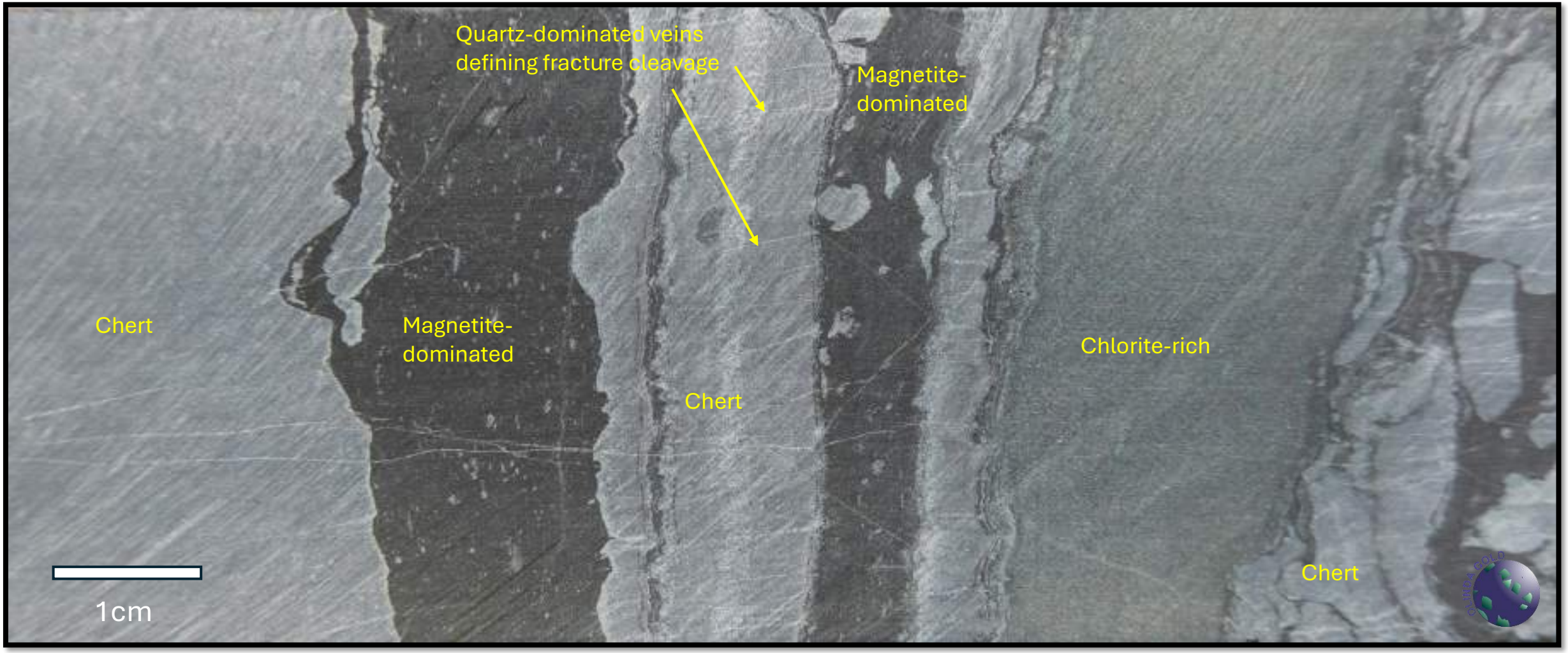

Chlorite-rich
Chlorite-rich
Chert
Magnetite-dominated
Chert
Magnetite-dominated
Magnetite-dominated
Chlorite-rich
1cm
OLINDA GOLD

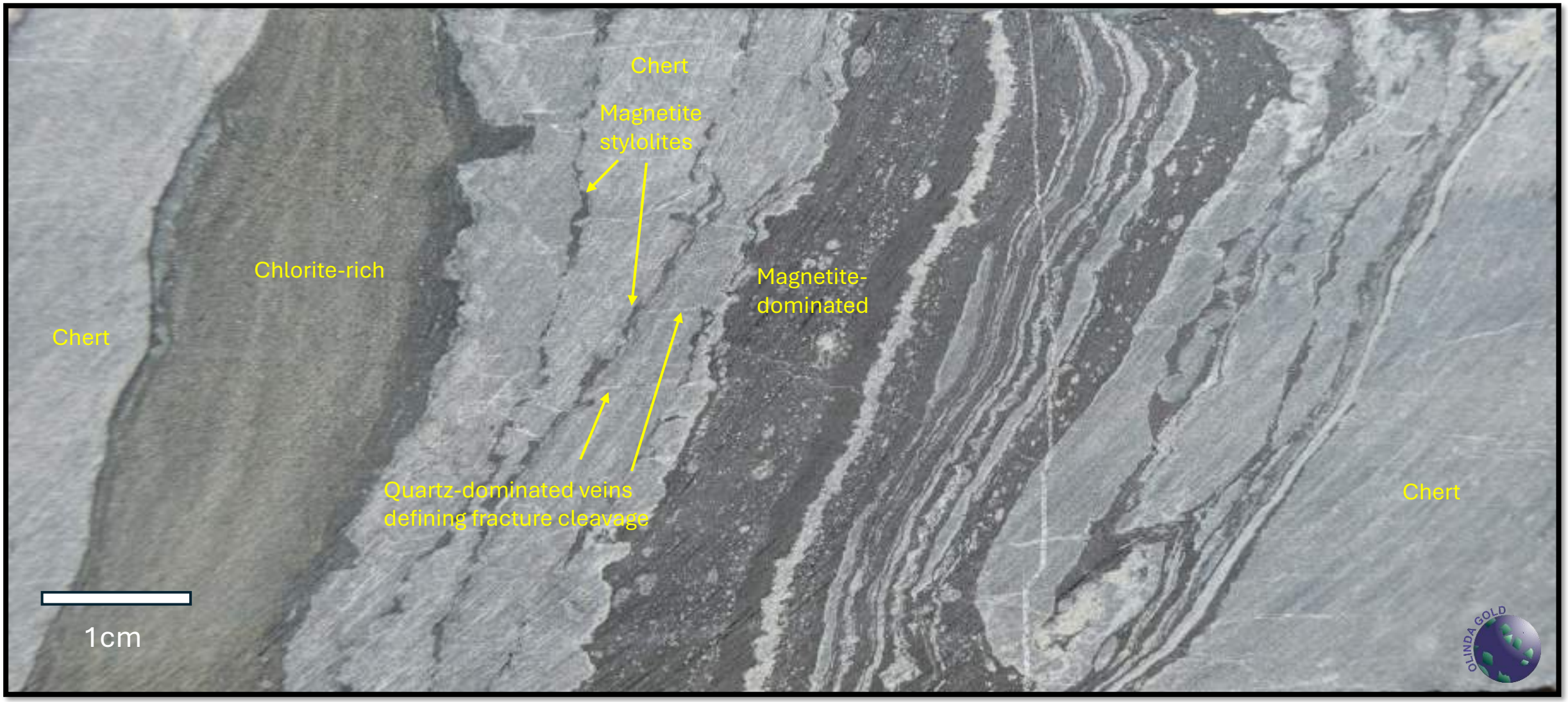

Chlorite-rich
Magnetite-dominated
Chert
Chert
1cm
Chert
Magnetite-dominated
Detail in next photo


Quartz-dominated veins defining fracture cleavage
Chert
Chert
Chlorite-rich
Magnetite-dominated
Magnetite-dominated
Chert
1cm


Chert
Magnetite-
dominated
Detail in
next
photo
Chert
Chlorite-
rich
Chert
Chlorite-
rich
1cm


Quartz-dominated veins defining fracture cleavage
Magnetite-dominated
Magnetite-dominated
Chert
Chert
Chert
306.0
1cm
OLINDA GOLD


Quartz-dominated veins
defining fracture cleavage
Magnetite-
dominated
Chert
Magnetite-
dominated
Chert
Chlorite-rich
Chert
1cm


Chert
Magnetite stylolites
Chlorite-rich
Magnetite-dominated
Chert
Quartz-dominated veins defining fracture cleavage
Chert
1cm


Chlorite-rich
Magnetite-dominated
Quartz-dominated veins defining fracture cleavage
Magnetite-dominated
Chert
Chert
1cm

Comparison of wet (top) and dry (bottom) photos

Photos have been taken of dry drill core that has been polished with wet-and-dry sandpaper.

There is too much reflection, and the magnetite-rich horizons are too dark to show detail in wet core, at least for a mediocre photographer like me.