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SELENOCHROMATIC ADDENDA
VIII

"The monkey looks into the mirror and sees a gazelle." ~ *arabian proverb*

The analysis procedure showed in the previous addenda is so thorough to it can be used also for semi-professional articles composition but surely it isn't easy. Selenohromatics should have a faster and easier approach, something like a first-look-method, so in this addendum we will try to set up a more extensive relation between chronology and colors, one of the most intriguing seleno-chromatic challenge. The majority of the Moon tints are holded in the maria areas, so it's normal approaching our problem exactly starting from these basalts. How nice it would be to say 'this is red, so it's old; this is blue and accordingly young'. Reality isn't always so clear and we have to start to summarize the principal events of the Moon history to start on the right foot. We are aware about the five lunar geological periods, from youngest to the oldest: Copernican, Eratosthenian, Imbrian, Nectarian and pre-Nectarian (Aitkenian).

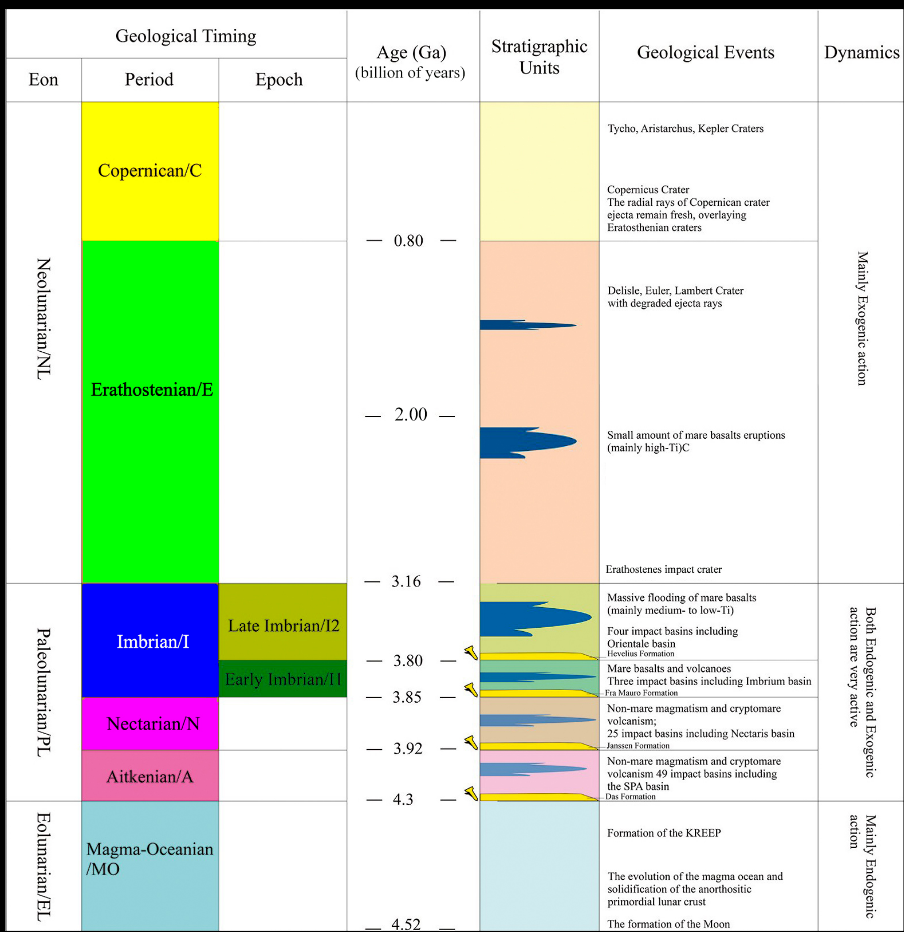

Fig. 1: a classic geologic lunar time scale (modified from [5])

Although some effusive activity started before 4 Ga (very low Ti wt% cryptomare deposits) [11][12], the most of the mare basalts formed during the Imbrian period about 3.2–3.85 (first peak) [2][8][10] continuing until 2.2–1.8 Ga in Oceanus Procellarum (second peak) [3], an elevated heat-producing elements region[9]; finally, a small basalt percentages erupted until around 1 Ga. Returning to the selenochromatics, we have learned that the red means FeO rich basalts and blue their high content in TiO2. Now the question is: we can find a relationship between colors, time and space? Let me just say ahead that there are a good news and there are bad news. The good are that we have reached the goal to relate the Ti wt%, color and the ages of the basalts. The bad news are that it isn't possible everywhere.

A wonderful world

There is a place on the near side of th Moon where we can affirm that warmer colors correspond to older basalts and colder tints to youger areas. Moreover, data confirm a progressive enrichment of the maria basalt in TiO_2 (with a lower rise in FeO, from there the blue prevalence!) content with time, at least for the exposed materials dating since the late-imbrian epoch and expecially for above 5 and 17 wt% content respectively; the increase occurred during a relatively short period of time near 2.3 Ga (blue shift). [3]. And even we are able also to correlate ancient mare remmants with a neutral color[4], so the red fades with the time, we can say. This lucky place roughly corresponds with PKT Procellarum Kreep Terrane (Mare Procellarum, Imbrium, Cognitum, Insularum), but also the closer areas Frigoris, Serenitatis, Vaporum Humorum and Nubium [3][4][7].

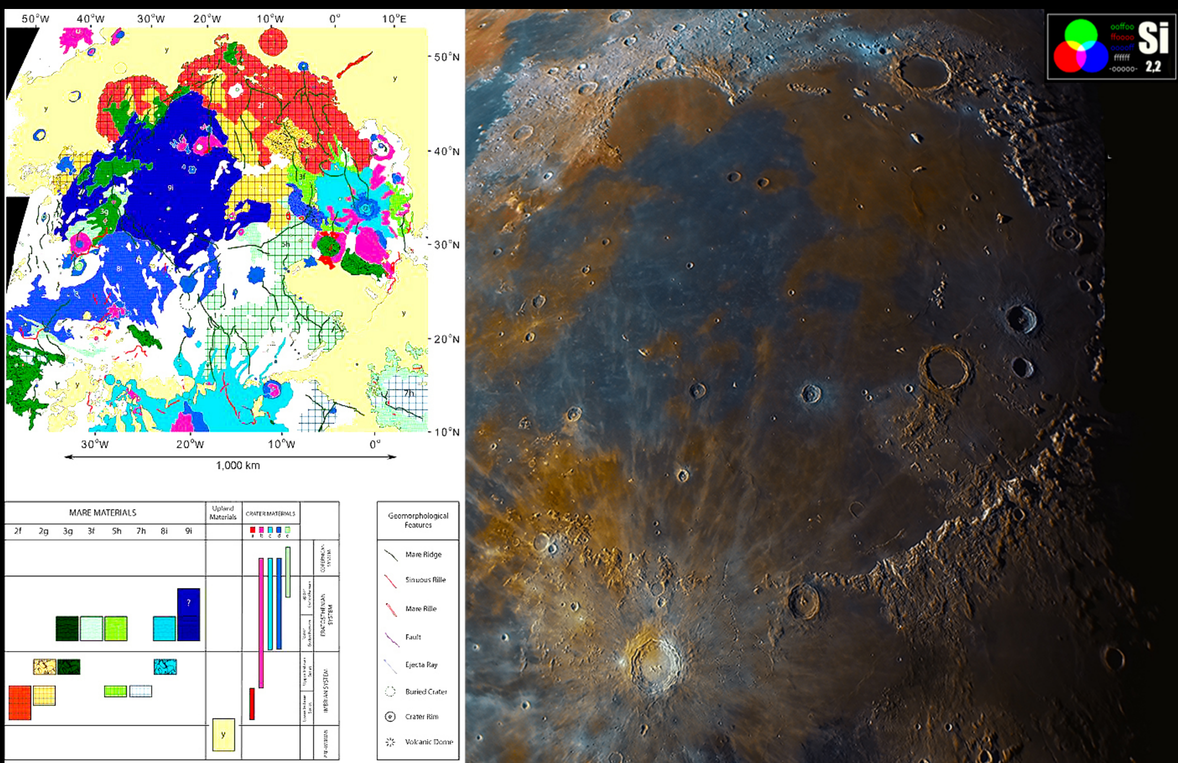

Fig. 2: Geomorphological map of Mare Imbrium region[3] and selenocromatic image by Serafino Vinco

Different studies effort the idea that the 'blue shift' (a change of content in TiO2) of the *Maria* magma took place around 2,3 Ga. The underlying mechanism falls outside the argument we are discussing but the interesting for us is that, excluded the contamination from highlands, before of this cut-off we will find only warm areas, after we will see only blue basalts. That's easy, it's great!

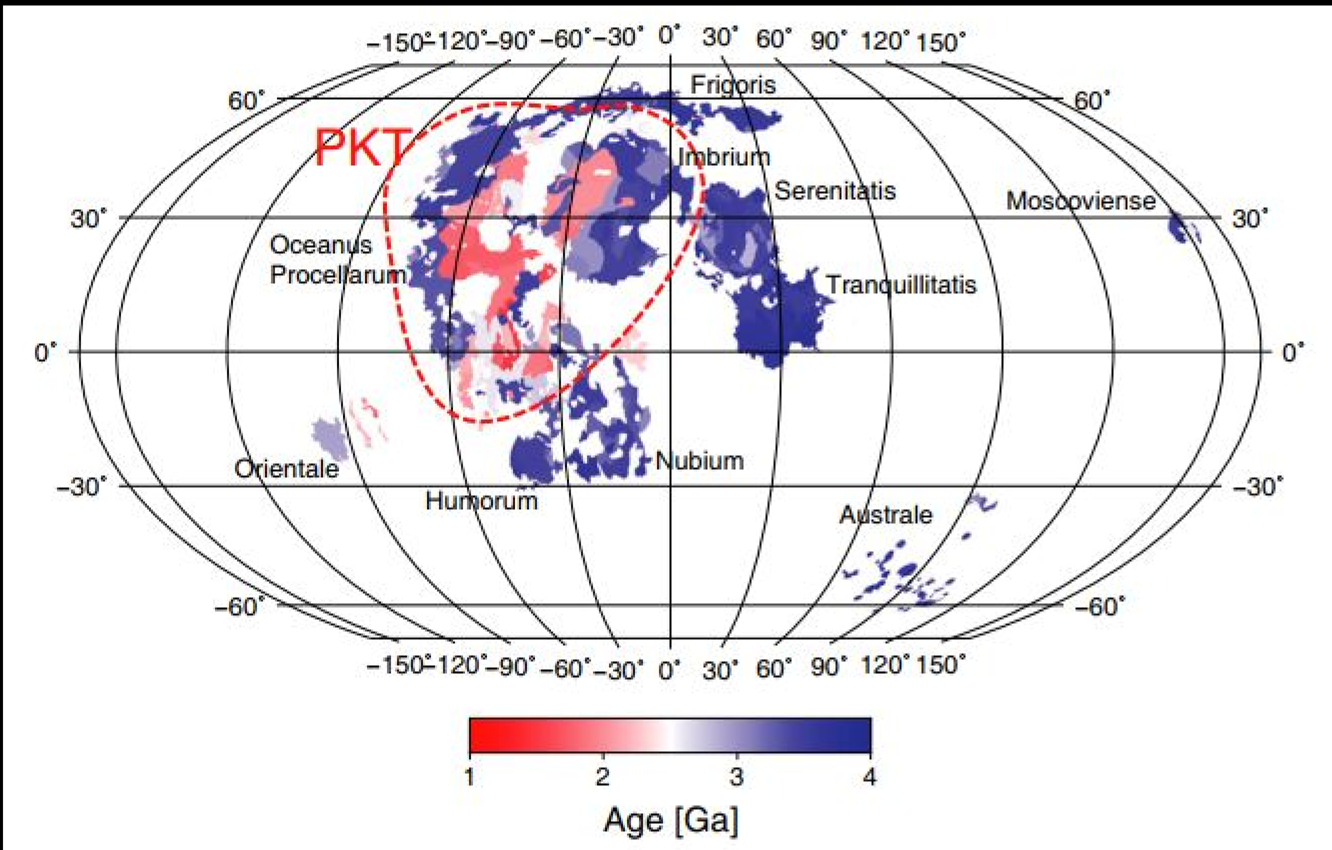

Fig. 3: Global map of the model ages of mare basalt units; highlighted the PKT area [2]

Where the chaos (seems) strikes again

Unfortunately Ti content of the *maria* units outside the PKT-Nubium demonstrates the failure of the relation between this content in wt% and age of the mare units: even when the eruption ages are the same the titanium content changes and so the colors.[2] And we reach the same conclusion with the lonely presence of blue basalt older than 3.0 Ga. The situation is well explained by Mare Tranquillitatis, were we can find ancient high Ti content units beside younger high Ti content units and young reddish basalts close to older warm basalts, both with the same tint! Sure, these tints appear less brilliant (red) and darker (blue) than those into PKT-Nubium, due an more intense aging effect (the *maria* average age is higher in the western lunar hemisphere[3][4][6]) but this don't permits us to date these basalts because our evaluation is so hardly affected by the variability of solar light incidence and probably, by a different geological origin, tichness and stratigraphy (vertical contamination) to result simply rough.

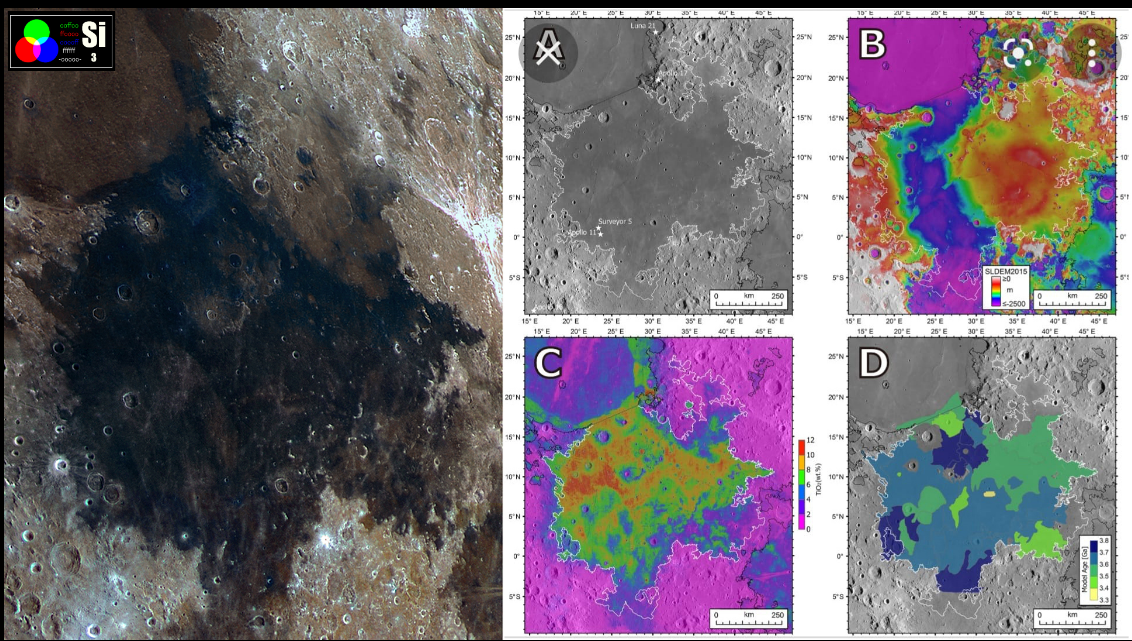

Fig. 4: Mare Tranquillitatis 'Si' by S. Vinco and A. Ferruggia to the left, remote sensing (B-C) and chronological data (D) to the right. [7]

That's a shame but observing more accurately Fig.3 we note that the chronologic figure 'D' showing absolute ages of *mare* units isn't useful to us: we are searching for a chromatic structure that divides the time at the same age (roughly) of the eratosthenian 'blue shift' (2-2,3 Ga). So, it's possible that in the short future we will decide to overcome the exposed issues with crater density or craters aging but, without prejudice to employ the three-step approach explained in the previous addendum (Selenochromatic analysis). But now let me emphasize that in Seleochromatics we should identify also a color-guided method, although it might appear gross.

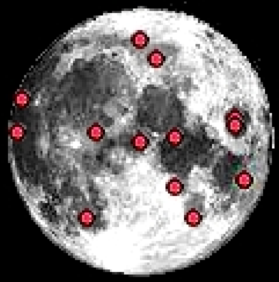

Fig. 5: main eratosthenian craters: Eratosthenes, Archytas Cavalerius, Seleucus, Manilius,Plinius Bullialdus,Aristoteles, Theophilus,Timocharis, Peirce,Langrenus,Picard, Cavalerius, Fracastorius

In other words, does exists a blue-shift-like phenomenon also out of the PKT and Nubium area? Yes, it is, at least regarding Tranquillitatis, Fecunditatis and Nectars Maria: infact on the their edges we find eratosthenian craters with chromatically still detectable ejecta. Thus, they might be considerated guide-craters as they are the oldest colored craters able to cover older areas. In the figure D ejecta of eratosthenian craters are not considered because of a too old classification (3,3-3,8 Ga) but their presence on the mare basalt divide helpfully the lunar chromatic timeline in a *pre*- and in a *post*-event and so it permits us to correlate colors and time (Fig.5). Reconsidering Map D, it has at first look suggested an inevitable chaos out of PKT but now we can debunk it to simply irrilevant for us!

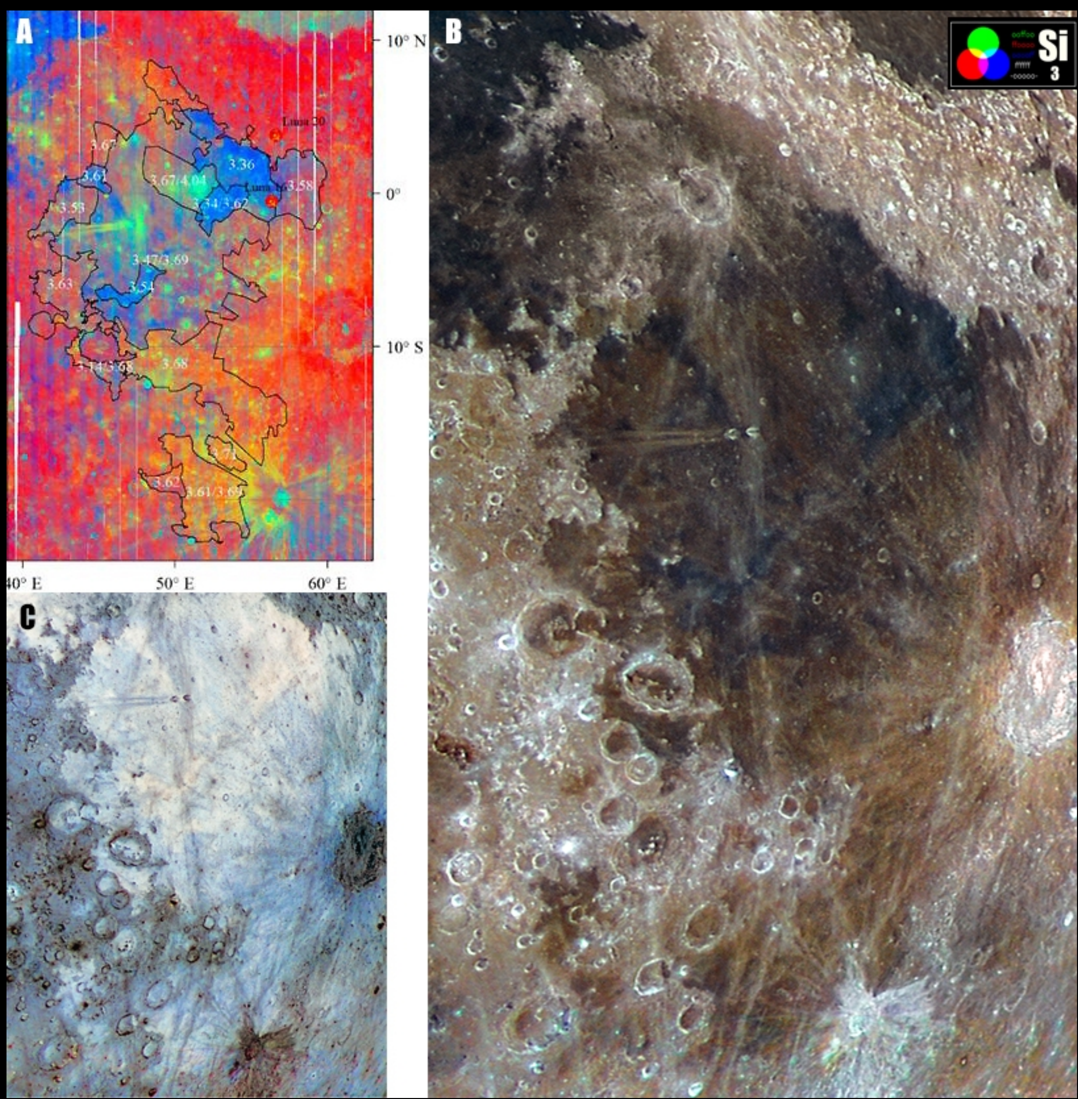

Fig. 6: A: Mare Fecunditatis age model[14], B) S. VINCO-A. Ferruggia's Si image, C: negative image

Take for instance the Mare Fecunditatis surface (Fig. 6): on the western edge it presents the great eratosthenian crater Langrenus whose sunbrust covers most of basaltic area. We easily detect brown shades surrounding the rays axys (helpful colors inverted images). These colors are higlands and melt materials degradated by the time with mixing micro-craterization. Furthermore we can reasonably account all the areas covered by Langrenus rays older than 3,1 Ga (an early erathostenian crater potentially is 3,1 old) and we can confirm it[13]. Hence, colored basaltic areas able to break an eratosthenian ejecta ray might be considered as younger eruptions (lighter areas in negative)[14] or areas capable of a more intense ejecta chromatic degradation(?).

Brief selenochromatic history of the Moon

Fig. 7: Si image of Theophilus area; note ejecta of the great Neo-Chromatic crater extended from M. Nectaris to Mare Tranquillitatis on Meso-Chromatic basalts; Serafino Vincos's image

After all these early considerations we return to tell our story to to grandmother (do you remember Einstein?) Ok, let's go. Apart from the gray-brown shades originating from criptomaria contamination (DHCs included), we are aware of the absence of important color information coming from a period before than Imbrium epoch. We can name this long time **Paleo-Chromatic** (ancient chromatic) Eon (Fig.8). Afer this we can define another long eon as **Meso-Chromatic** (chromatic of the middle) eon, dominated by blue/red huge volcanic effusions. Two event cut-off this eon: 'blue shift' and eratosthenian craters, respectively in the eastern and westwrn hemisphere. The advent of the oldest colored rays craters coincides with the end of this eon and with the beginning of the **Neo-Chromatic** one ('new chromatic', from 2,3 Ga to the present). To be honest fixing *ad hoc* this time-point we make somewhat of forcing (eratosthenian craters age rage from 3,1 to 1,1 Ga in geological timeline) but remembering that the central selenochromatic target is to undersand the Moon we can suggest another time its meaning: when arrived colored craters almost the whole basalt floodings were accomplished in the western hemisphere.

During this period we observe the youngest craterization, also on copernican layers: infact are frequent Bright Halo Craters (intense azure) and Dark Halo Craters (blue or red) on recent *ejecta* areas. Summarizing it happens that Nectarian period 'eats' the pre-Nectarian; the Copernican become longer 'eating' the late Eratosthenian; the remaining time, before the blue shift cut-off, is named 'chromatic in the middle' (sum of Imbrian and early Eratosthenian period). So reamain only three eons (instead of five periods). That's too hard? Grandma! Grandma! Sssh, sleeps deeply. In any case it results a semplified-color-related-timeline, alternative to the geological one and this, for now, might be enought for us. Surely the attempt to correlate colors and time is not complete but, we can always use the classical analysis method to rate undecifrable areas.

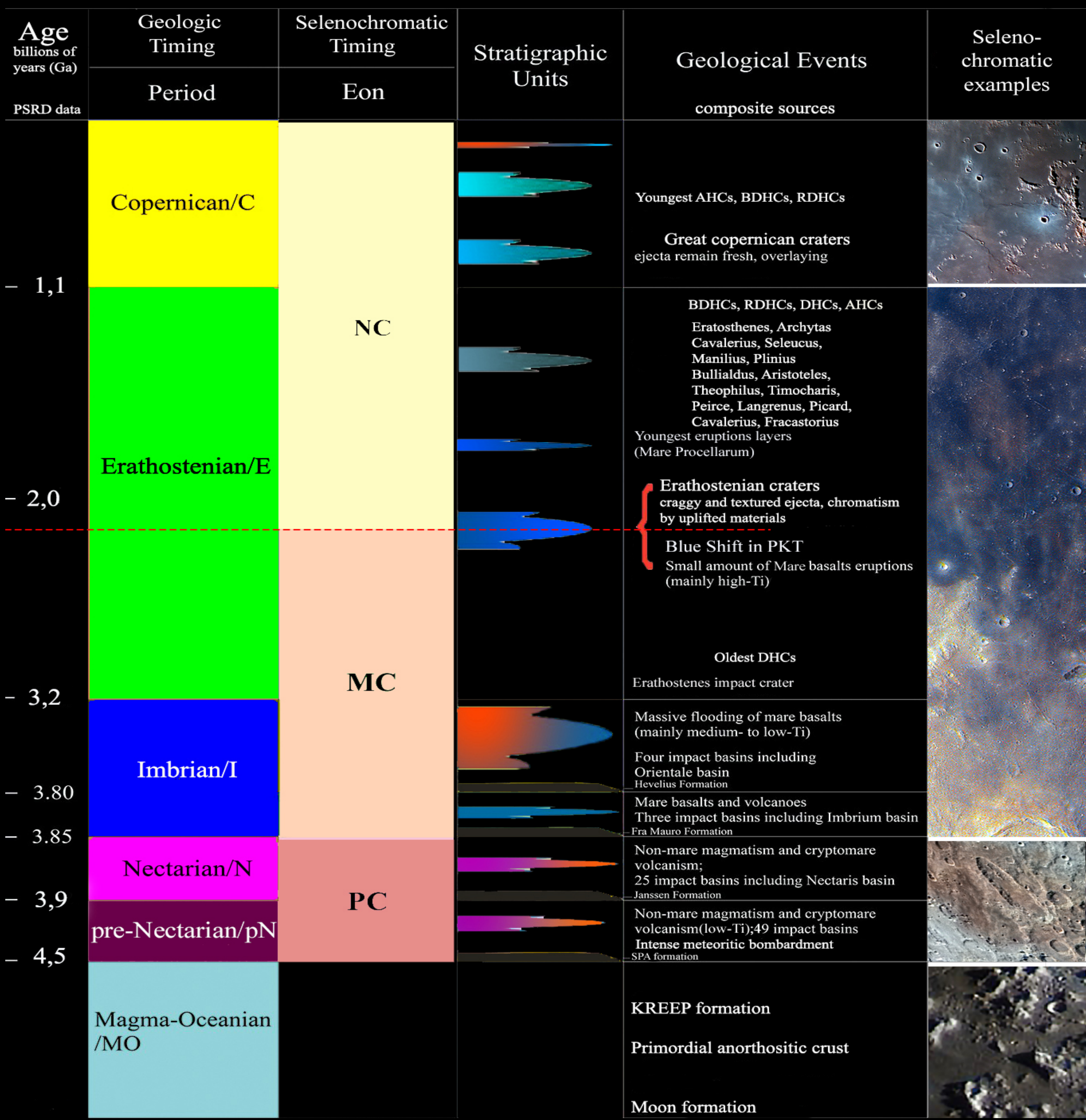

Fig. 8: Comparison between geologic and selenochromatic timescale; note the semplification of three eons (sum of periods) instead of five periods and the 2,3 Ga cut-off (dashed red line)

Finally we can regard some eminent chromatic landmarks like 'The Red Theophilus' as chronological landmarks, also if we have the chronic problem of do not see too many gazelles.

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