CARBON ON THE MOON: CONTRIBUTION OF DARK COLOR FOR MOON SURFACE ROCKS

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Abstract

Origin of **dark color** on the Moon surface has been explained by significant **carbon content** supplied from **impact quenched process**, based on data of **the Apollo ro**cks, **lunar meteorite**, and **artificial laser** sputtering experiment, and comparison with **representative Earth's rocks**, where the Moon impacted surface is considered to be **carbon-bearing dark colors** on **carbon-rich quenched Mare** and **brecciated rocks**.

Introduction

Black and white colors on the Moon surface have been explained by **topographic albedo** and **colors of minerals in the rocks** [1-2]. **New contribution** of color on the Moon surface is discussed by significant **carbon contents** of **the Mare** and **Highlands** based on **blackish carbon contents** from **bulk composition** and comparative **carbon-bearing textures** formed **naturally** and **experimentally** as main purpose in this study.

Previous explanation of Moon's colors

Clear black and white on the Moon? ⇒ NO! Dark colors of blackish & whitish stones!

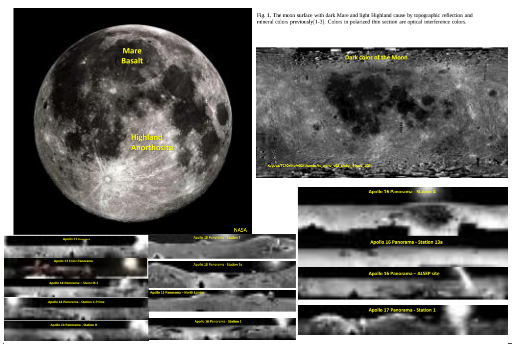
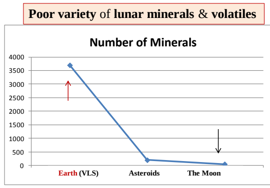


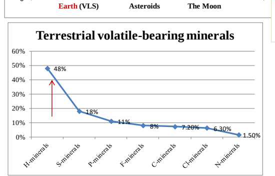
Fig. 1. The moon surface with dark Mare and light Highland cause by topographic reflection and mineral colors previously[1-3]. Colors in polarized thin section are optical interference colors.

Anomalous minerals of the Moon

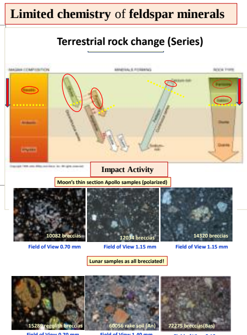
Moon minerals obtained from **the Apollo samples** & **lunar meteorites** show **anomalous aggregates** with **poor variety** of lunar **minerals** & **volatiles,** and **limited** composition of **feldspar-crust minerals**. **Anomalous** data are originated from **fluid-poor dry activity** (with **carbon**) [4].

Poor variety of **lunar minerals** & **volatiles**





Limited chemistry of **feldspar minerals**



Carbon contents of Moon rocks

Carbon contents of reported **Moon's rocks** are exceeding higher in **soils-regolith breccias** and **polymic breccias** than **Mare basalts**, which indicates that **impact process** produces higher **carbon-bearing rocks**, as shown in Fig.2 [2, 7].

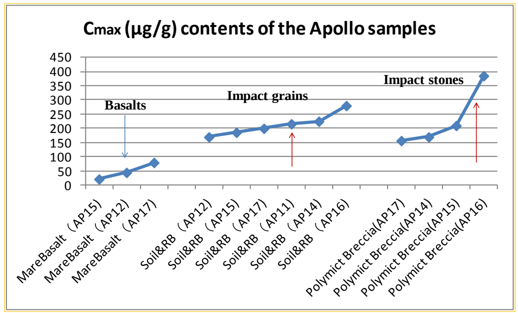


Fig. 2. Maximum carbon (Cmax) contents of Mare basalts (Apollo, AP-12, 15, 17), soils and regolith breccias (Apollo 11-12, 14-17) and polymict breccias (Apollo 14-17) reported [2, 7]. This indicates that car-bon contents are higher in impact-mixed samples.

Carbon contents of Earth's rocks

Carbon contents of **1,500 Earth's samples** with recent **carbon-XRF instrument** show **carbon contents** (> 2.0 wt.% CO_2, except carbonates) from **light to dark Earth's rock colors** (Fig.3):
1) Whitish light plutonic granite has **less carbon**. **Volcanic** rhyolite shows **higher carbon**.
2) Higher carbon content is obtained in **fine volcanic rocks** than **coarse plutonic** rocks.
In short, **dark colored rocks** of the **Earth's rocks** shows **higher carbon contents** relatively, whereas **less carbon** amounts in **quenched** volcanic rocks with **fine** textures [6, 7].

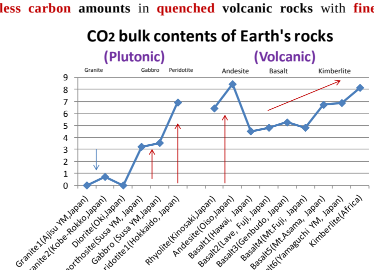


Fig. 3. Bulk carbon contents of representative Earth's rocks from silica-rich to poor chemistry, light to dark colored optics, and coarse plutonic to fine volcanic texture. The bulk data have been measured with recent XRF instrument (with carbon analyses) [6, 7].

References

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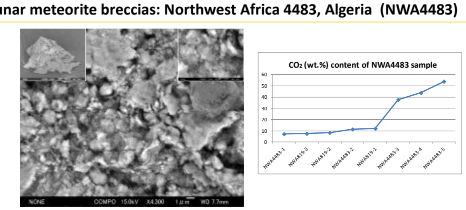
Artificial formation of carbon-bearing textures

From our laser experiments make two carbon-bearing micro-textures [5-7].
1) **Mechanical breaking texture** with linear **micro-** and **nano-grains.**
2) **Fluidal melting texture** with irregular **micro-and nano-grains.**
The present **results** of **higher carbon-contents can be used to volcanic rocks** [5, 7].

Nano-grains of Moon's rocks by the FE-ASEM

In order to observe lunar carbon-bearing texture, we have observed **carbon-bearing solidified texture** and contents of lunar meteorites of Northwest Africa 4483 (NWA4483 breccias) and Antarctic Yamato 86032 (Y-86032) as shown in Fig.4 [5,7].

Lunar meteorite breccias: Northwest Africa 4483, Algeria (NWA4483)



Lunar meteorite: Yamato 86032, Antarctica (Y-86032)

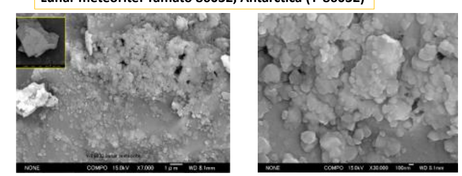


Fig. 4. Carbon-bearing nano-grains of lunar meteorites (Northwest Africa 4483, NWA4483 breccias and Ant-arctic Yamato 86032, Y-86032) with the FE-SEM with the ZAF calculation [3, 4]. This indicates that carbon has been reserved through impact fluids to solidified texture of the lunar samples.

Conclusion

1) Origin of color on the Moon surface is discussed by **carbon contents** and **texture**.
2) Carbon contents of Moon's rocks are caused by **impact solid** for soils & breccias.
3) Earth's rocks include **higher contents** in **dark colored** and silica-poor rocks.
4) Artificial **laser sputtering** process produces **carbon-bearing textures** by melting.
5) **Carbon-rich texture** is obtained at **lunar meteorites** (NWA4483 & Y-86032).
6) **Air-less Moon** shows **carbon-bearing dark colors widely** and **quenched rocks.**

Acknowledgements

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