SURFACE REGOLITH BRECCIAS FORMED BY SHOCK EVOLUTION ON THE MOON AND ASTEROIDS RELATED WITH HUGE NUCLEAR EXPLOSIONS.

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Introduction: Impact materials on the surfaces of air-rich planets and airless Moon (or Asteroids) are classified as major two kinds of material evolution from target rocks of crystalline rocks (Earth-type planets) and regolith soils with many voids, glassy and crystalline grains, respectively. The main purpose of the paper is to elucidate shock evolution of surface regolith soils on the Moon and Asteroids, by applying carbon-bearing products on huge explosions of terrestrial and lunar impacts related with artificial nuclear energy.

Various impact materials on two target rocks: Hard crystalline target rocks of the air-rich planets (Earth, Mars and Venus) show shock evolution of the shatter cone or shocked minerals of quartz which can be estimated from target rock by single impact as shown in Table 1 [1, 2]. On the other hand, airless Moon and Asteroids reveal regolith soils with many voids, glasses and crystalline grains by multiple impact mixing processes, which are called "agglutinates" on the Apollo lunar samples [3-6] (Table 1). The multiple impacts produced as regolith soils and breccias with crystalline minerals and rocks show similar textures of evolved rocks by deeper magmatic evolution process by stable high temperature- pressure condition [5, 6].

Table 1. Shock evolution on two types of impact rocks .

Target rocks	Shocked materials
1) Hard crystalline rocks	Shatter cone, shocked grains. Air-planets (Earth, Mars).
2) Regolith porous soils	Agglutinates, breccias. Airless Moon and Asteroids.

Remote IR spectral data of lunar surface: The previous remote-sensing data of the IR spectra on airless Moon and Asteroids are based mainly crystalline *minerals* of regolith soils and/or breccias, though basement rock type without any root is estimated on the remote IR data. This is mainly because all materials of regolith soils and breccias on the Apollo lunar samples are *without basement root* of rolling stones [3-6]. In fact, there are two crystalline data sources of crystalline (minerals and/or rocks) fragments and matrix (crystalline in 68501, intermediate in 75081, and glassy in 15299) on the Apollo lunar regolith samples (Fig.1) [3, 4].

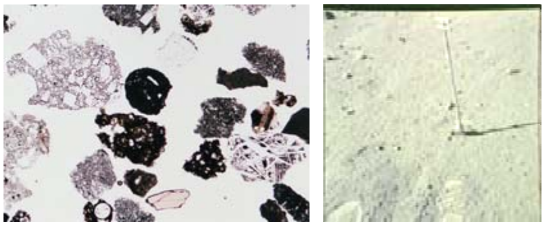

Fig. 1. Apollo 68501 highland regolith soils as collected photo (right), and its optical micrograph by plane polarized lights with image width 4mm (left) [3, 4]. The remote IR spectral data are mainly based on crystalline *fragments* of regolith soils or breccias glassy coated [6].

Characteristic shocked minerals on the Moon: The following data suggest characteristic lunar shock evolution different with terrestrial magmatic evolution with slower cooling [1-8]:

1) Number of minerals on the Moon is *less than* about 10% than that of terrestrial minerals [5, 6], which suggest that estimated lunar basement rocks have *few alteration* by any hydrothermal activity.

2) Major crustal minerals of plagioclase shows a) higher amounts of foreign *Mg and Fe* [7], b) *a few vacant site* in feldspar composition (without major cation elements) [7], c) Ca-rich plagioclase contains *carbon element* [7], d) lunar plagioclase has few exsolved lamellar textures [8] which are different with terrestrial rocks with slow cooling.

3) Characteristic indicator of shock evolutions is not the latest mineral and/or rock features but any elemental concentrations of *carbon, chlorine* and *rare-earth elements* (REE) in the lunar breccias [7].

4) Lunar regolith soils show multiple shock melting process to be younger ages [3, 4].

Analyses of shocked regolith breccias: The lunar surface with multiple shock evolution has following characteristics for material identification and crustal evolution:

1) *Pristine* lunar highland rocks covered by mega-regolith (up to ca. 2km in depth) [3, 4], are difficult to obtain due to multiple melting impacts [5, 6].

2) Regolith thickness on younger front side based on later basaltic rocks are different with far side based on older highlands, which makes difference in *thickness of lunar crusts* on final both sides [6].

3) *Impact effects* on regolith soils are different with those of crystalline rocks, because of many voids, glasses and crystalline grains on mega-regolith [6].

4) Crystalline and glassy fragments on mega-regolith are *repeated changes* of states by slow or rapid cooling process at multiple smaller and larger impacts [6].

5) *Central peaks* are not the remnants of deeper crust but *final crystalline blocks* of glassy regolith blocks due to relatively slow cooled glassy regolith at central peak of the lunar regolith crater [6].

6) Multiple shocked materials with *carbon* can be estimated from a) huge *terrestrial* craters (esp. *ocean-impacts* with water and crust rocks, which are *mixed* with slow and rapid cooled materials during excavation steps) [9, 10], and b) huge *artificial* impact explosions (esp. nuclear energy explosions, which are mixed with various cooled materials at *air* and/or *sea* explosions) [11, 12]. In this sense, the regolith evolution on the Moon and Asteroids should be compared largely with any characteristic features on *mixed artificial* materials with crystals and glasses with carbon [6].

Carbon contents of lunar impact samples: From reported data of the Apollo lunar samples**,** impact materials of lunar *regolith soils* and *breccias* contain *higher carbon* contents as shown in Fig. 2 [4-7], which suggest that higher carbon contents is characteristic of *impact mixing process*.

Carbon contents of meteoritic samples: Carbon contents of *E-chondritic* meteorites from Asteroids show higher contents with higher *iron* metallic contents as shown in Fig. 2, though there are largely higher carbon contents obtained at carbonaceous chondrite estimated as impact remnants of air-rich planetary body [5-10]. There are *few* reports of in-situ surface materials at *glassy regolith soils* of airless Asteroids so far [6].

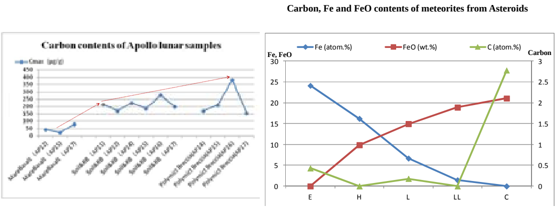

Fig. 2. Carbon contents of the Apollo lunar samples (left) and chondritic meteorites with Fe and FeO (right) [6, 7].

Carbon contents of products at artificial nuclear explosions: In order to select huge *impact mixing* materials on the impact craters and/or artificial huge explosions, melting materials of the Hiroshima nuclear energy explosions formed on August 6th, 1945 in Japan are used in this study due to *systematic record* of distance from center of explosion after formal permission from the Hiroshima Memorial Museum [10-12]. Any systematic distance data are not obtained at melting products on the Nagasaki (Japan) and Trinity site (New Mexico, USA) in this study.

Carbon contents of the Hiroshima shocked materials: The *highest carbon* contents can be obtained in the center of explosions [11], where dust, soot and other materials (including organic calcite [11, 12]) flung up from the ground surface formed "*black smoke*" and dirt soot with water-drops in the air to form "*a black rain* " fallen later. Detailed FE-ASEM analyses of the melted materials from center of explosions (*ca.*150m) to 4,600m show gradual decrease of carbon contents on selected carbon-bearing melting materials (shown in Fig.3 [10-12]).

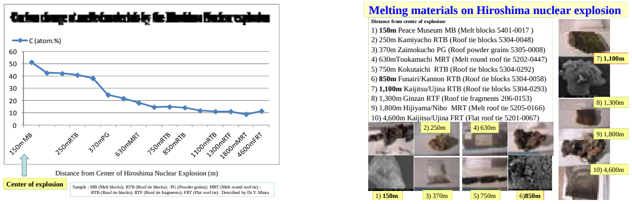

Fig.3. Carbon contents of the Hiroshima nuclear energy explosion products from center of explosion to outside (left) and detailed of used samples of the Hiroshima nuclear explosion with photos and some FE-SEM images (right) [11, 12] selected by author.

Summary: The results are summarized as follows:

1) Surfaces of airless Moon and Asteroids are mainly covered with regolith breccias formed by multiple impacts.

2) Carbon content is one of indicator of huge impacts of the Apollo lunar regolith breccias and chondritic meteorites (from Asteroids), though any reports of glassy regolith soils of airless Asteroids are expected.

3) Nuclear energy devices used can be applied to obtain more *detailed* data for *impact materials* in airless bodies.

4) Higher carbon contents are obtained near at *center (i.e. central peak* site) of the Hiroshima huge nuclear explosion in the air after mixing melted materials with quenched rain.

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