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MORPHOLOGICAL CONSIDERATIONS ON THE LOCAL CONVECTION PROCESSES AND SELENOLOGICAL HISTORY

BY

Schunichi MURATA

Kochi Technical College, Kochi, JAPAN

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ABSTRACT

The processes of the formation of i) the Central Meridianal Horst, ii) the two large seleno-faults which situate near the N-30° and S-30° latitudes (*i.e.,* Frigorium Fault and Cichus Fault), and, iii) the Circum Imbrian Tectonics (*i.e.,* Nubium Strait, Serium Strait and Frigorium Trough), are discussed with respect to the result of the drift of silicic mass blocks due to mantle convections that correspond to the spherical harmonics of the first order and second order, and the other local convections. Especially, with regard to the formation of the two seleno-faults, following three successive processes are discussed: (i) The Central Meridianal Bulge was raised up by the first order convection, (ii) the Central Meridianal Horst was appeared between the two local convections, and (iii) finally the zone in the Central Meridianal Horst, bounded by the north and south 30° latitude lines, was drifted by the superior convection of these two. We examined the above three processes fully, with referring to Spurr's selenological history.

Asymmetry of Mare Imbrium is discussed with consideration of hypothesis of the drifting silicic mass blocks due to local convection.

The fire lines of the ray craters are discussed on the basis of the above mentioned processes.

With reference to rock-ages and to Spurr's selenological history, We pointed out that resurgences of the lunar diastrophysm occurred every 0.3×10^9 years.

§1. Introduction

Spurr has published a series of monographs, "Geology Applide to Selenology", almost thrity years before the succesful events that U.S. astronauts could bring back the lunar samples. In spite of this long lapse of time, his books still remain much suggestions with excellent interpretations and deep insights, though some modification would be necessary in modern aspects. The major foundations, extended in Spurr's selenology, are summarized in the following two:

(1). *Dome inflation and collapse processes for the formation of Mare Imbrium.*

At the beginning, surface layer of the Moon was fluidal basic, and silicic solid (or plastic film) covered entire surface. Silicic crust was formed by differentiation of ultrabasaltic magma. Then, a gigantic dome inflation, *i.e.,* domical uplift, occurs by enormous gas accumulation, but becomes deflate in the accompanied degassing process and finally collapses. The sequence of these processes formed ringed maria, *i.e.*, Mare Imbrium and others.

(2). *Periodic restoration of diastrophysm and subsequent phenomena.*

Selenological history is schematically divided into three, *i.e.*, Proteroselene, Mesoselene and Teleoselene ears, by the stages of thermal evolution:

1). *Proteroselene*

1. *Early*

   The primordial surface, relatively firm or probably plastic.
   Skelton of crater and fault ridge. (Primitive complex).

2. *Middle*

   Virtual (Nominal) cessation of rotation, due to capture of the earth.
   Development of polar grid-system and earthward bulge.
   Remelting. (Melting of the surface layer).
   Long and high meridianal ridge in lunalite.

3. *Late*

   Development of larger Graben-craters, and deformation of them by appression and oppression.

4. *Close of Proteroselene*

   Revolutionary period.
   Uplift of Central Meridianal Horst.
   Uplift of Imbrian and other domes.
   Crustal slipping along Cichus Fault zone.

2). *Mesoselene*

1. *Early*

   Beginning of Imbrian dome deflation.
   Relaxation and cementation of early Imbrian Faultsystem and of Central Meridianal Horst.
   Growth of domical uplift of Ptolemaeus and Clavius type.

2. *Middle*

   Revolutionary period.
   Collapse of Imbrian dome and others.
   Crustal slipping along great seleno-faults (Frigorium Fault).
   Formation of caldera craters (Copernicus, Theophylus and Tycho etc.).

3. *Late*

   Remelting and warping. Thinning of crust in southwestern region.
   Growth of great "flat-bottomed" craters (Schickard type).
   In southern central regions, growth of great and small craters of the Stöfler type.
   Growth of large caldera craters between Mare Frigoris and Mare Imbrium.
   Global appression.

3). *Teleoselene*

1. *Early*

   Freezing old mare surface and of craters.

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* The word "silicic" is used in habitual fashion instead of modern expression, "anorthositic". (See –**6**).

** We underlined the items for which careful attentions are needed.

Formation of wrikle ridge on mare surface.
Further deepening of mare basins and of Mare Imbrium.
Renewed lave-flooding over the surface.

2. *Middle*
Revolutionary period.
Further enlargement of mare basins.
Novabase flooding.
Ash explosion.

3. *Late*
Freezing of novabase crust.
Supramare craters.
Opening of fissures in both lunalite and lunabase.

§2. Survey of the Earth-side Features of the Moon

In this section, brief descriptions on the lunar features in Spurr's terminology are given with some comments for the further discussion in the later §3 and §4.

(1). *Central Meridianal Horst*

The dark-tincted maria and the light-colored terrae are prominent characters on the Moon at the earth-bound surveying. No maria are found on the far-side and many, on the earth-side. Estimated area of the maria is approximately 30 percent. But along the central meridianal zone of the earth-side surface, a bulk of the terra in mushroom shape can be seen with its top on the lunar south pole. This Central Meridianal Horst, in Spurr's terminology, was deformed and erased in the process of Imbrian Mare formation on the northern hemisphere. In Figure 1, Spurr's drawing is reproduced for later reference.

Now we follow his survey for a while: North polar region is relatively depressed and flattend and erased. On the other hand, in the south polar region, Central

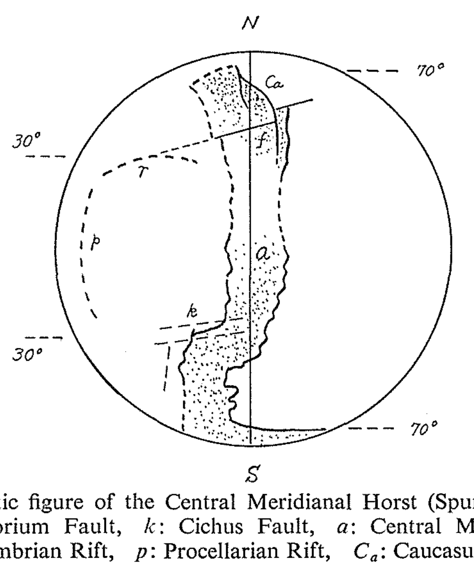

Fig. 1. Schematic figure of the Central Meridianal Horst (Spurr, 1949).
f: Frigorium Fault, *k*: Cichus Fault, *a*: Central Meridianal Horst,
r: Rorimbrian Rift, *p*: Procellarian Rift, C_a: Caucasus Fault.

Meridianal Horst spreads to the west. This feature of the south pole is called positive cap, while the negative cap, at the north pole. Along the 30° and 60° of north and south latitude, there are critical zones where appressions and major faultings occurred. Near S–30° latitude, the Cichus Fault System had recurrent activities from the Proteroselene to the Teleoselene era. Cichus Fault extended and reached the neighbering region of Schickard at the late Teleoselene ear. This Cichus Fault zone indicates the alternating history of compression and relaxation. Similar "alternation" are found not only on the Central Meridianal Horst in remarkable but in other places. Spurr explained this alternation as the resurgence due to isostatic adjustment. The earth-ward bulge was occurred at the middle Proteroselene and the Central Meridianal Horst formed at the revolutionary period, *viz.*, at the end of the late Proteroselese. After these events, Imbrian dome inflation followed. When the middle Mesoselene era entered the revolutionary period, crustal slipping occurred and, Frigorium Fault was formed. This formation process of the Central Meridianal Horst was proposed by Spurr already. The followings are cited again from Spurr's monographs for our later discussions: "The segment of the ridge left between the two polar segments, or between lat. 30° N and 30° S is truly central meridianaly, and it is proposed that this arrangement may be explained by a shifting of the Moon eastward on its axis, after its capture, this shifting the horst from its central portion; and a subsequent swinging back, under telluroselenic attraction, of the more equatorial crust, bringing this portion of the crust back into central meridianal position".

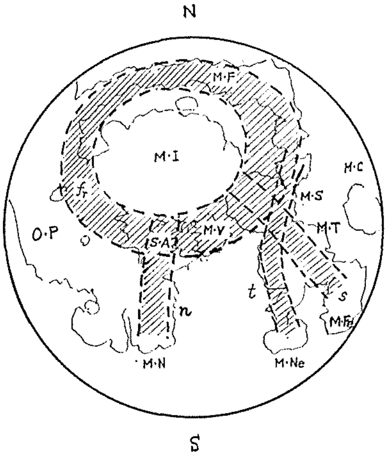

Fig. 2

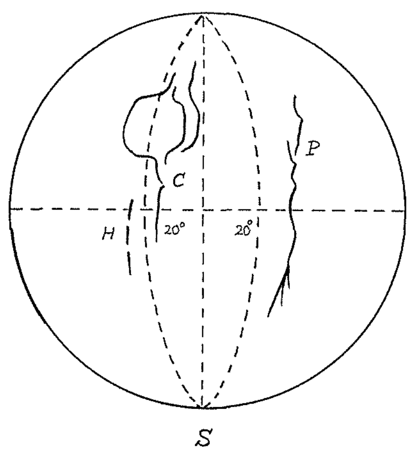

Fig. 3

Fig. 2. Schematic figure of three large Circum Imbrian Tectonics (Spurr, 1945). The line *t* is Seretranect Strait supposed by Murata (1974). See §3. (3). f_r: Frigorium Trough, *n*: Nubium Strait, *s*: Serium Strait, **M·I**: Mare Imbrium, **M·S**: Mare Serenitatis, **M·V**: Mare Vaporum, **M·F**: Mare Frigoris, **M·T**: Mare Tranquillitatis, **S·A**: Sinus Aestuum, **O·P**: Oceanus Procellarum, **M·F$_e$**: Mare Fecunditatis, **M·N**: Mare Nubium, **M·N$_e$**: Mare Nectaris.

Fig. 3. Schematic figure of the zones that are suffered strong appression (Spurr, 1949). **C**: Copernicus zone, **P**: Posidonius zone, **H**: Humonubium Riphaen Ridge.

(2). *Tectonics*

There are three large tectonics around Mare Imbrium. One is the Frigorium Trough that surrounds Mare Imbrium and contains Mare Frigoris, some parts of Mare Serenitatis, Mare Vaporum, Sinus Aestuum, and a part of Oceanus Procellarum. See Figure 2. The second is the Nubium Strait that starts from Mare Imbrium, passes the east of Copernicus, through Sinus Aestuum, and extends far to Mare Nubium. The last tectonics is the Serium Strait that passes through the center of Mare Serenitatis, and reaches Mare Fecunditatis *via* Mare Tranquillitatis though this strait is faint. These three tectonics and Mare Imbrium were formed at the same time of the middle Mesoselene.

(3). *Appression zones*

The zones affected by appression are shown in Figure 3. The Copernicus zone is located near the W-15° meridian line and Posidonius zone, near E-30°. The Humo-Nubium ridge divides the southern part of Oceanus Procellarum into Mare Humorum and Mare Nubium. Montes Riphaeus is the extension of the Humo-Nubium ridge. Procellarian rift traverses Oceanus Procellarum. These appression zones contain many faults, wriknle ridges and lines of blow-holes. These were affected by appression and oppression alternately, and this feature is due to shrinkage of the Moon, in Spurr's terminology.

§3. Formation of the Circum Imbrian Tectonics

In this section, we follow the process of mantle convection on the Moon and discuss its effects on the lunar tectonics.

(1). Our proposed convection process on the Moon is as follows: Both fluidal maria and plastic silicic mass blocks were produced by large scale differentiation at the early Proteroselene. Afterward, at the middle Proteroselene a convection (in the lunar interior) which corresponds to spherical harmonics of the first order, exposed the out-let *a* on the earth side. The silicic mass blocks were drifted toward the far-side by this convection, and then, the distribution of maria and terrae were formed as we can see today, *i.e.,* thick silicic terrae on the far-side and maria on the earth-side. See Figure 4 and Figure 5. At the same time, the earth ward bulge appeared as a meridianal ridge on the earth side, by the effect of the out-let of this convection. This process was maintained by Miyamoto (1967, 1968) already.

The second order convection superposed over the first order, as shown in Figure 6 and Figure 7. The effect of this second order convection was not so conspicuous as the case of the first order, but its pattern in corresponding to the spherical harmonics of the order 2, as shown in Figure 8. In this Figure 8 the shaded area represent the positive, and the blank area, the negative: the zone between N-35° and S-35° latitude lines is negative and corresponds to depressed maria zone on the earth side, and also corresponds to the distribution of large basins or tharasoids on the far-side, *i.e.,* Pasteur, Moscoviense, Texas, Ciolkovskij, Korolev, Kibalčič, Mare Orientale, Mare Australe, Mare Ingenii and also Raspletin along the belt between N-35° and S-35° on the far side. Here we call attention to both critical lines of N-35° and S-35° latitude.

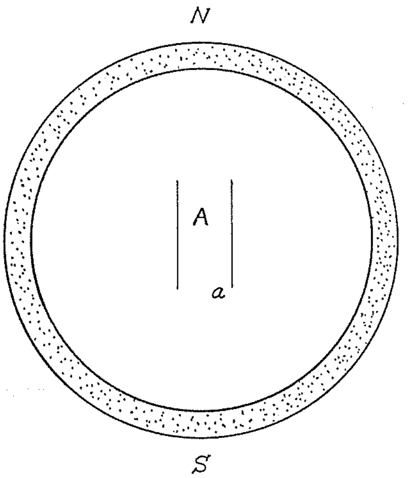

Fig. 4

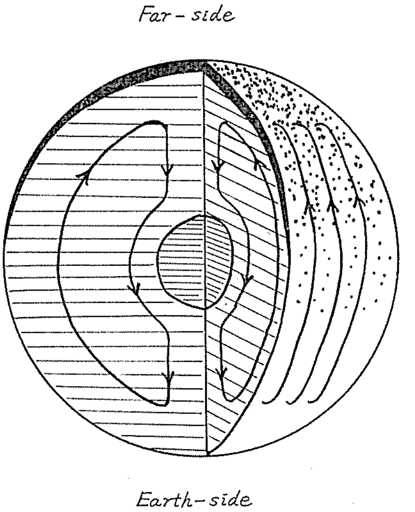

Fig. 5

Fig. 4. Schematic figure of the first order convection on the earth side. The first order convection is marked with **A**. The zone *a*, bounded by the two parallel lines, is the out-let of the convection **A**. Earthward bulge appears on this zone. Dotted area is the zone where silicic mass blocks are accumulated.

Fig. 5. Schematic representations of the convection currents on the surface and in the interior. These currents are caused by the first order convection with a samll core.

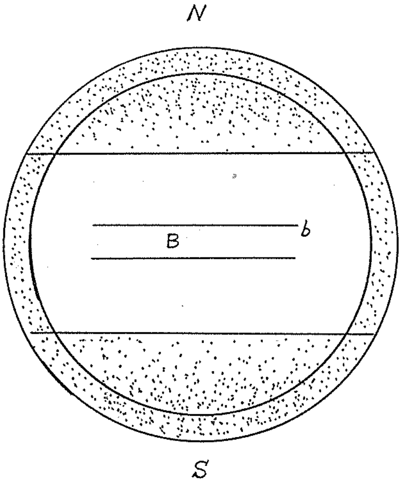

Fig. 6. Schematic representations of the effect due to the second order convection **B**. The region, *b*, bounded by two parallel lines, is a ridge, and is the out-let of the convection **B**.

There should be a convection corresponding to the spherical harmonics of the third order, but its evidence on the Moon is faint. The topography of the negative cap of the north pole and the positive cap of the south pole would be the traces of the third order convection.

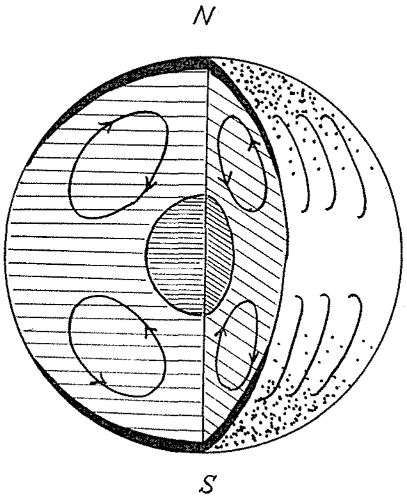

Fig. 7

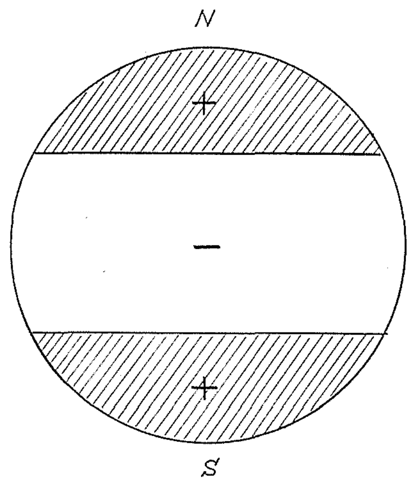

Fig. 9

Fig. 7. Schematic figure of the second order convection. Dotted and black regions are thick silicic crust drifted by this convection.

Fig. 8. The patters of the spherical harmonics of the second order. The shaded area is the zone where $P_2(\sin\theta)>0$, and blank area, $P_2(\sin\theta)<0$.

The first order and second order convections are global but the higher orders are rather local. Some of the evidence of the first order convection are already shown by Miyamoto (1968) and by Lingenfelter *et al.*, (1973). Similar evidence are found in the model of the lunar crust. Models of the crust (Wood, 1973 and Anderson, 1974) are deduced from the analysis of the laser observation and the lunar seismic waves (Latham *et al.*, 1972; Toksöz *et al.*, 1974). According to these models, the crust is thick on the far-side and thin on the earth-side. Center of mass offests 2 km earthward from the center of the lunar figure. This features an evidence of the first order convection. Regarding some other effects of the second order convection, Runcorn (1962) and Fielder (1965) maintained their opinions respectively.

(2). At the period of the late Proteroselene, two large local convections **C** and **D** (the out-lets *c* and *d*, respectively) occurred on the earth-side as shown in Figure 9. By the effect of these two local convections, the silicic mass bolcks were drifted to the central meridianal bulge, and the Central Meridianal Horst was born as it is seen today. Generally, at the out-let, the ridge is formed, and a rift grows within the ridge and the rift indicates the tensional pattern. By these convections **C** and **D**, this central meridianal rift are compressed, and a long high Central Meridianal Horst ridge was born. This Horst revealed alternative features receiving both tension and compression.

The local convection **C** was more dominant than the **D**, and therfore, the zone, bounded by N-30° and S-30° lines at the Central Meridianal Horst, was drifted eastward, similar to Continental Drift on the earth (Runcorn 1952), and the Frigorium Fault *f* and Cichus Fault *k* were formed (Figure 10). Accordingly, these two great seleno faults *f* and *k*, were formed at the period of the late Proteroselene. The regions *c* and *d* in Figure 10, are the out-lets and form the ridges, while the regions

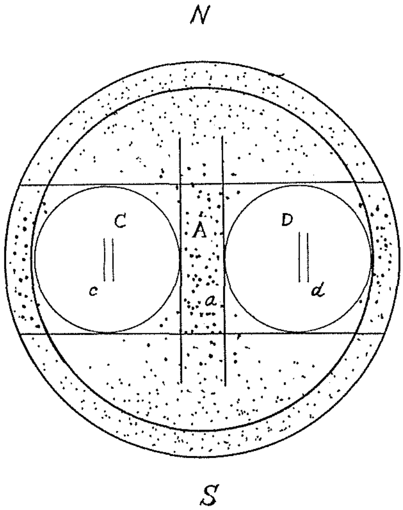

Fig. 9

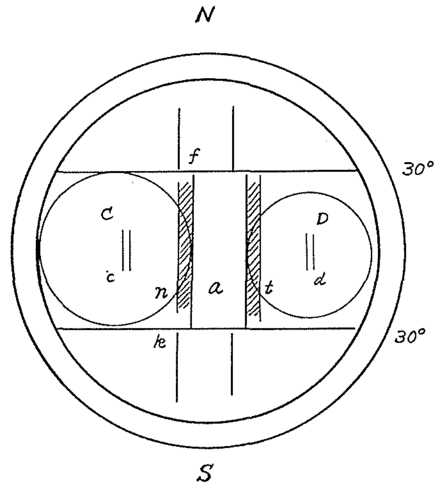

Fig. 10

Fig. 9. Schematic figure of the two local convections. Regions *c* and *d*, which are bordered by the two parallel lines, are the ridges corresponding to the out-lets of these convections.

Fig. 10. Schematic figure of the continental drift. The zone, *a*, is drifted by the convection **C**. The lines *f* and *k* are the seleno-faults. The shaded regions, *n* and *t*, are trenches.

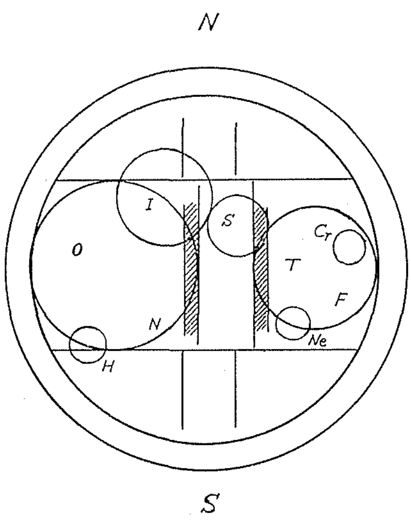

Fig. 11

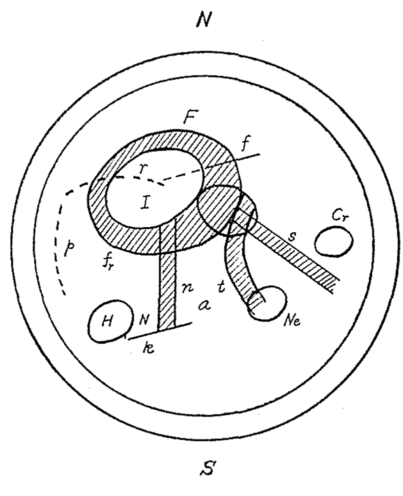

Fig. 12

Fig. 11. Schematic figure of the formation of the ringed maria. The ringed maria are formed along the edges of the two local convections.
I: Mare Imbrium, **S**: Mare Serenitatis, **H**: Mare Humorum, $\mathbf{C}_r$: Mare Crisium, $\mathbf{N}_e$: Mare Nectaris, **N**: Mare Nubium, **T**: Mare Tranquillitatis, **F**: Mare Fecunditatis.

Fig. 12. Schematic figure of the Circum Imbrian Tectonics.
f_r: Frigorium Trough, *n*: Nubium Strait, *s*: Serium Strait, *t*: Seretranect Strait, *a*: Central Meridianal Horst, *f*: Frigorium Fault, *k*: Cichus Fault, *r*: Rorimbrian Rift, *p*: Procellarian Rift.

n and *t* are the in-lets, and form the trenches. Succeeding to these two local convections, Imbrian and other domes began to inflate, and then, Mare Imbrium, Mare Serenitatis and other circular maria were formed. See Figure 11. Similar process is actually realized as the Plate Tectonics in geophysics today. At the boundary of two plates, a ridge (rift) or a trench or a fault line is formed. The ridge corresponds to the out-let of convection and the trench, to the in-let.

(3). Through the above mentioned processes, the lunar features shown in Figure 12 were formed finally on the earth-side. Regarding to Serium Strait Formation, this process is not effective. We consider a trench which passes through the west of those of Lacus Movtis, Lacus Somniorum, and Posidonius appression ridge, the east shore of Central Meridianal Horst and finally reaches to Mare Nectaris. Here let us call this trough "Seretranect Strait" (*t* in Figure 12). The ridges of *c* and *d*, shown in Figure 10, are the out-lets of the local convections **C** and **D**, and these ridges are hidden by the later mare lava inundation and they still remains as the deep seated weak structural lines. The appression ridges formed along these weak structural lines in the later era. Procellarian rift was the in-let of the convection **C**, and Copernican appression zone was settled along the out-let of the convection **C**. This zone shows appression ridges as for a crumple on the surface layer, but in actual, it forms deep seated weak structural lines. Whether convection is global or local, its activities and pauses repeated one after another. Thus, revolutionary period appeared at every active stage, and the features due to compression and tension have occurred alternately.

§4. Mare Imbrium Formation

(1). The asymmetry of Mare Imbrium were debated already as the weak point of Spurr's dome inflation and collapse theory. Miyamoto (1968) pointed out this defect and presented the local convection model: He showed that silicic mass (lunalite) blocks are drifting over the maria (lunabase). In the northward, in spite of a large quantity of accumulation of silicic mass, its boundary shows relatively gentle features. On the contrary, in the southward, when accumulation of silicic mass blocks is not so large, its boundary shows extremely steep as Montes Carpatus represents. In the westward, the lunalite mass blocks are not found, and Mare Imbrium extends to Oceanus Procellarum directly. But in the eastward, Montes Alpes, Montes Caucasus and Montes Apenninus form steep border line, though Serium Strait passes to Mare Serenitatis, a large amount of mass blocks are found in this region.

These features are deduced clearly by the process described already: Namely, in the north and eastward, a large amount of silicic mass blocks are accumulated by the convection **A**, **B**, **C** and **D**. The Montes Carpatus in the south is elevated due to out-let of the second order convection **B** or of the local **C**, at the equatorial Copernicus zone. With above mentioned processes, Mare Imbrian local convection occurs and makes silicic mass blocks expand around it, and therefore, steep scarps appeared both on the east and southward. In the northward, there are rich mass blocks, but the surface is not elevated, and remains moderate features. Some additional factors are effective. The direction of the convection current **B** of the second order on the surface tends to the north from the equator, and at the south boundary of Mare Imbrium on the surface the direction of the current of the

Mare Imbrian local convection opposite to the convection **B**. Accordingly, steep scarps are revealed there. In the northward, the direction of both current are the same, and the feature appears gently.

(2). Between the mass accumulation due to the first order convection **A**, and second order convection **B**, and another mass accumulation caused by the Mare Imbrian local convection **I**, Mare Frigoris was formed. Therefore, oppression ridge (east west ridge) was formed. The distribution of ridges is shown in Figure 13. Marking *a* is Frigorium Ridge, and *b* shows the effect of the compression between one of mass accumulation due to the convection **A** and another mass accumulation caused by the local convection **C**. Marking *c* is apparently appression ridges by the effect of the convection **C** and **D**. Further, *d* and *e* correspond also to appression ridge regions, though they are out-lets of the convections **C** and **D**.

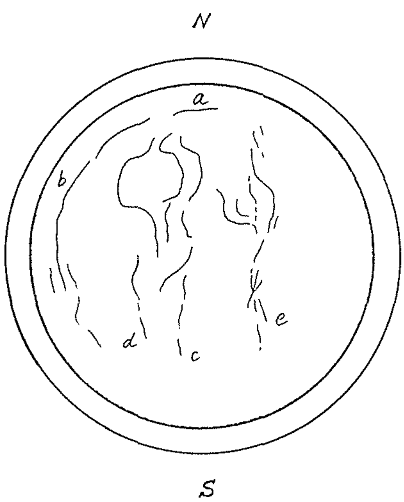

Fig. 13

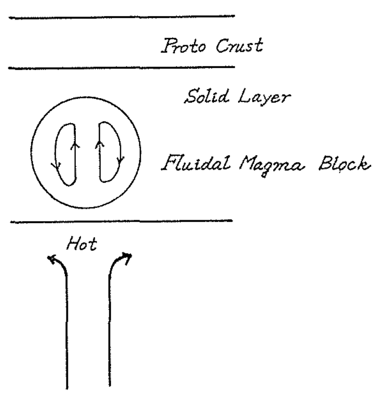

Fig. 14

Fig. 13. The major wrinkle ridges on the lunar earth-side.

Fig. 14. Schematic figure of the rising fluidal magmablock.

(3). We suppose that there was a domical uplift different from Spurr's dome inflation. The plastic film covered the surface of the fluidal basic magma incompletely, but the solid or plastic lunalite mass blocks floated over the solid or plastic basic layer. We refer this basic layer as to proto-crust. Now, let us consider that there was solid mantle under this protocrust and further, there was warm convection layer under them. See Figure 14. In this warm layer, when a large parental convection is excited, some part of solid mantle right above this convection changes to fluid phase. This magma block rose up in convecting state in the mantle, pushed up-ward the protocrust, and produced domical uplift before it broke out-let on the surface. The extreme outer boundary region would become the Circum Imbrian Trough, and this region sugged after a little inflation. Thus radial structure was enhanced by the original grid system.

§5. The Distribution of the Ray Craters

In a previous paper, we discussed that the ray craters have an apparent endogenetic origin, and pointed out the followings (Murata, 1974):

1). The ray craters are found on the terrae in general and when they are on the maria, they are found on the region where the lunalite is exposing.

2). They are found between the two ringed structures, or just on the edge of the ringed structure.

3). They enclose some hot regions (Shorthill *et al.*, 1965).

4). They ranged on some meridian lines.

5). They exist on the redder and reddish area in the combined photographs of the IR positive and UV negative (Whitaker, 1972).

6). For the ray craters, we estimated the ratio, r, of the diameter of the ray to that of the central crater. We marked craters with α' for $r>20$, α for $15<20<r$, β for $10<r<15$ and γ for $r<10$. We put these marks on a lunar map, and we fined some active fire lines.

While we follow the discussion of the formation processes on the Central Meridianal Horst and Circum Imbrian Tectonics, we corrected some of these fire lines in our previous paper (Murata 1974). The fire lines corrected from new stand point are shown in Figure 15. The circle (1), (2), (3) and (4) form the ringed structural lines of Mare Imbrium. Circle (3) forms the boundary of Mare Imbrium. Circle (4) forms the outer border of the Frigorium Trough. Circle (5) encloses Mare Selenitatis, and Circle (6) ranges on the ringed structure of Mare Crisium.

These circles form the weak lines of the ringed structures of the Mare Imbrium. The line (7) corresponds to the ridge of the out-let of the first order convection, and features the effect of the relaxation and also suffers strong appression by the local convections **C** and **D**. Regarding to these local convedtions **C** and **D**, their

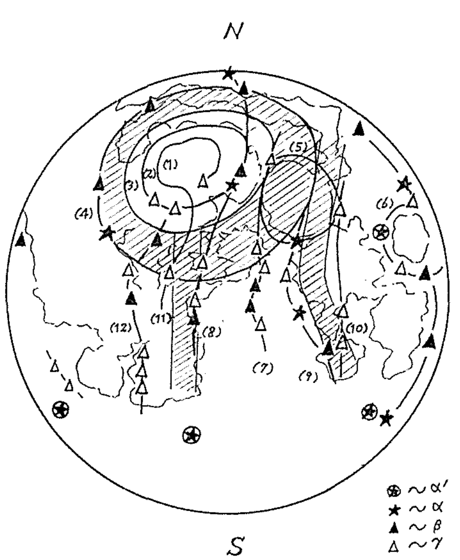

Fig. 15. Corrected fire lines that are inferred from examination of the convection processes.

activities and pauses repeated one after another, and therefore, we found obvious traces of alternation of compressions and tensions on this line. On the earth, the fire lines appears at the zones of in-lets (Benioff zone) or out-lets of mantle convections, *i.e.*, at the ridges or trenches. The lines (8) and (9) are passing along the tenches that correspond to the in-lets of the local convections **C** and **D**. The lines (10), (11) and (12) have some connections to the out-lets *c* and *d* of the local convections **C** and **D**, and ray craters are found along its deep seated weak lines. We made some amendments to the fire lines on the lunar surface. As to the fire belts of the ray craters, we would infer that there are two large groups: one is on the meridianal line, and the other, by the ringed curve. Meridianal line and ringed curve appeared along the weak structural lines, formed by the global or local convections.

§6. Rock-ages and Selenological History

A wide range of constraints were imposed by the data obtained by lunar missions, especially those by Apollo experiments and rock-samples. Many works on lunar thermal history were presented (Cross, 1970; Gold, 1973; Toksöz *et al.*, 1972, 1973, 1974; Heamed, 1973). Especially Toksöz *et al.* (1973) and Iriyama (1974) indicated the correlation between rock-ages and lunar thermal history.

(1). It is currently accepted that the maria are made from mare basalt and terrae from anorthosite or anorthositic gabbro. If the lunar highland is anorthositic, extensive differentiation on the Moon should be required (Wood, 1970; Ringwood, 1970; Mizutani *et al.*, 1973; Toksöz *et al.*, 1973; Turkevich, 1973; Taylor, 1973; Mizutani, 1974; Anderson, 1974). From the rock-age analysis, Toksöz *et al.* showed that there was extensive differentiation on the Moon at about 4.6×10^9 years ago in lunar history. This consists with Spurr's selenology. According to Spurr's hypothesis, the surface layer of the Moon would be completely in melted state just before the large-scale differentiation had occurred. At the period of the early Proteroselene, the Moon was entirely covered by silicic solid or plastic film, and this stage was caused by extensive differentiation. Therfore, the word "silicic" in Spurr's history, corresponds actually "anorthositic".

(2). According to Iriyama's rock-age analysis (1974), anorthosite of Apenninus was formed by reheating at about 4.1×10^9 years ago. This period is the middle Proteroselene in Spurr's history, and this reheating was the remelting in Spurr's terminology and was resulted from the first order convection **A**.

(3). According to rock-age analysis, the rocks of Cayly Descaltes and Framauro were formed at about 3.9×10^9 years ago by re-crystallization. This period corresponds to the first revolutionary period which continued from the end of the late Proteroselene to the early Mesoselene in Spurr's history. The Central Meridianal Horst was formed by the process of the two local convections **C** and **D**. Recrystallization was performed by the activities of these two local convections. There were maria basin excavation by impact at the same period, in their history, while Imbrian and other ringed maria were excavated by the domical uplift and small local maria-formed convections in our history.

(4). Tranquillitatis was formed at about 3.6×10^9 years ago in their history based on rock-ages. This period corresponds to the second revolutionary period at the middle Mesoselene in our history.

(5). Fecunditatis, Imbrium and Procellarum were formed at about 3.3×10^9 years ago according to rock-age history. This corresponds to the third revolutionary period at the middle Teleoselene in our history, and ray craters were appeared by ash explosion and novabase flooded.

(6). By the comparison of these two histories, we can find that the Spurr's Revolutionary periods appeared at every about 0.3×10^9 years, and remelting and lava flooding were repeated (Ronca, 1973; Cruikshank *et al.*, 1973). This resurgence of diastrophysm occurred by the alternation of activities and pauses of the local convections **C** and **D**. Table 1 shows parallelism of two histories.

Table 1. Parallelism of Toksöz's and our history. Chronology is fixed by age-determination for the following samples.

b.y.	4.5	4.0	3.5	3.0
Toksöz's history	KREEP	12013, A–14, 15415, A–16	A–11	L–16, A–12, A–15
		Framauro, Cayly, Descaltes	Tranquillitatis	Procellarum, Imbrium, Fecunditatis
	Differentiation of Initial Crust			
	Igneous Activity, 8 Basin Excavation		Mare Basin Filling	
era	Proterosolene		Mesoselene	Teleoselene
	Early	Middle Late	E. M. L.	E. M. L.
Our history based on Spurr's		R.P. Remelting	R.P. Remelting	R.P. Remelting
		Remelting		
		First Order Convection	Two Large Local Convections	Freezing Old Mare, Wrinkie Ridge
	Extensive Differentiation		Central Meridianal Horst	Novabase Flooding
	Primordial Surface	Earthward Bulge	Crustal Slipping	
			Two Seleno Faults	
			Domical Uplift (Dome Inflation)	Ash Explosion
		2nd Order Convection	Small Local Convections (Dome Collapse)	
		Polar Grid System	Circum Imbrian Trough, Caldera Crater	Supramare Crater

KREEP: K (Potassium), Rare Earth Element and Phosphorus.
12013: Number of Lunar samples.
15415: Number of Lunar samples.
A-a: Lunar samples by Apollo-a experiment.
L-b: Lunar samples by Luna-b experiment.
R.P.: Revolutionary period in Spurr's history is shown by R.P.

§7. Conclusion

We interpreted the formation of the Central Meridianal Horst and Circum Imbrian Tectonics by the convection processes. Especially two large local convections were very important. After the Central Meridianal Bulge was raised up as the outlet of the first order convection, this Bulge was put between two large local convections and Central Meridianal Horst was formed by silicic mass blocks due to these local convections. The zone between N-30° and S-30° latitude of the Central Meridianal Horst was drifted eastward by the more superior local convection of these two, and therefore, Frigorium and Cichus Fault were formed. The Frigorium Trough was formed with Mare Imbrian domical uplfit and Imbrian local convection. Nubium Strait and Seretranect Strait were appeared as the trenches which correspond to in-lets of the two large local convections.

These local convections are effective not only for formation of the tectonics on the lunar surface, but for the followings: (1) Asymmetry of Mare Imbrium, (2) the fire lines of the ray craters, (3) rock-ages and our selenological history.

Mare Imbrian asymmetry is largely due to the amounts of silicic mass driffted by the two local convections and to the elevated topography caused by the outlets of these convections.

Both fire circles and lines represent the deep seated weak structural lines. A ray crater may be found on both circles and meridianal lines (for example, Pytheas, Gambart, Manilius, Agrippa and Menelaus *etc.*).

Our selenological history consists with history based on rock-ages. Three resurgences of diastrophysm are interpreted by the alternation of activities and pauses of the local convections at every 0.3×10^9 years.

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