Galactic Dynamics + their Geological Consequences

This paper has three objectives; to summarize the data and hypotheses presented by Johann Steiner in his article "The Sequence of Geologic Events and the Dynamics of the Milky Way Galaxy"[1], my main source article; to probe more deeply the basis of a hypothesis of a non-constant gravitational "constant"; and to give some of my own thoughts and questions about the consequences and validity of the use of the hypothesis to explain geological findings.

In his article, Steiner demonstrates rather remarkable correlations between numerous geological events and the position of the solar system along its galactic orbit for approximately the last one and one-quarter cosmic years. (a cosmic year being the period of rotation of the sun around the galactic center, approximately 280 million years) The sun's path approximates a Kepler elipse with a retrograde rotation of the major axis around the galactic center. The sun is now rapidly approaching its perigalacticum of 0.995 of the present galactocentric distance of about 27,000 light years. The apogalacticum is 1.145 times the present distance. Due to the retrogression of the axis ~~of the major elipse~~, the approaching perigalacticum is our second during this cosmic year. Steiner considers four points along the curve of galactocentric distance versus time (Figure 7a) as being significant; the two perigalactica, the apogalacticum, and the two "critical slopes" - where the rate of change of galactocentric distance is maximum.

I have included two of Steiner's figures showing the relationships of various geological events and our galactic posistion. It is apparent that there is an interrelationship.

Steiner uses two glactic variables to explain these relationships, an empirically derived galactic gravitational function, and a weak but significant galactic magnetic field. Some of his data, clusterings of cosmic ray exposure ages of meteorites around the present and last two perigalactica, he leaves unexplained. The majority of the geological correlations are explained in terms of one or the other of two effects of a variable G; contraction and expansion of the earth, and increase and decrease of the solar constant. Steiner, applying the Mach principle*, developes an empirical function of G (the Newtonian gravitational "constant") versus galactocentric distance. He bases it on the known function of galacto-orbital velocity versus galactocentric distance of stars. The G function is plotted in Figure 2. This scheme is complicated by what Steiner calls the Dirac-Jordan effect; the decrease of the absolute values of the curve with time as a result of the expansion of the universe. (see Figure 2) The effect of this linear variable on G in the vicinity of the sun is sketched against time in Figure 7. This effect, which causes a regression of the critical slopes to slightly earlier times is used to help explain data which do not exactly correspond with the simple model.

G has a direct effect on the solar constant. An increased G

*that changes of the total distribution of mass surrounding two bodies changes the interractins btween the bodies decreases the diameter of the earth's solar ~~constant~~ orbit, increasing the solar constant as the square of the decrease in the radius. This effect is comparatively minor. The energy output of a star is proportional to G, according to the equation:

$$\underset{\text{(luminosity)}}{L} = \underset{\text{(mass)}}{M^{11/2}} \; \underset{\text{(radius)}}{R^{-\frac{1}{2}}} \; \kappa^{15/2} \quad \text{where } \kappa = \frac{8\pi G}{c^2}$$

(κ is the Einsteinian equivalent to G)

Jordan[2] states that the solar constant is proprtional to a little less than κ^{10}. The fit between the data for paleoclimate and the expectations ~~of~~ from the change of solar constant is striking, as can be seen in Figure 7.

The other major postulated effect of change in G is cyclic contraction and expansion of the earth as an inverse function of G. Steiner gives two estimations of the magnitude of the dependence of terrestrial radius on G.

1. Dicke at al. (on basis of elastic model): $\frac{\delta r}{r} \approx -\frac{1}{10} \cdot \frac{\delta \kappa}{\kappa}$

2. Jordan (on basisof phase change model) : $\frac{\delta r}{r} \approx -\frac{\delta \kappa}{\kappa}$

He uses this relationship to explain major stratographic and orogenic period tendencies as well as periods of maximal sedement-ation and paleolatitude change rates. He relates maximal geosyn-clinal subsidence rates with maximal expansion rates. He also relates the maxima of coal and oil production to quick burial due to fast subsistance. The explosive evolution of certain plant and animal genera and classes he relates to changes in climate and availability of terrestrial versus marine ecological niches due to marine regression and transgression. Many of these relationships are shown in figure 8.

The other correlate of the earth's galactic "season" that Steiner suggests may have a geological effect is the weak galactic magnetic field. This field runs parallel to the spiral arms of the galaxy and is considered to have opposite direction on either side of the galactic plane. Assuming a simple model in which "the rotational axis of the earth maintains its mean orientation with respect to the galactic standard of rest",(Steiner,p.122) and assuming that the earth has any sort of precessional or other movement around this mean axis; then the chances of a particular orientation of the rotational axis to the galactic magnetic field would be a function of the orientation of the mean axis of the magnetic field. This mean orientation, under this model, is a matter of galactic "season". Figure 9 may show this relationship more clearly. If it is further assumed that the galactic field is strong enough to influence the direction of the earth's magnetic field, this model predicts obtained trends in magnetic field direction over the last 400 to 600 million years. This model helps support the self-exciting dynamo hypothesis by supplying a weak initiating field and an explanation for specific directionality of the magnetism.

The concept of a variable G apparently has developed along several lines other than Steiner's empirical evaluation of intragalactic phenomena. There seem to be two major points of departure for these branches. The first is the Mach principle of dependence of inter-particular forces being dependent upon the total distribution of mass in the universe. Dicke[3] and Steiner base their work on this principle. The other branch began with Dirac's[4] observation which he considered a fundamental principle that " Any of two of the very large dimensionless constant numbers of cosmology and atomic theory are connected by a simple mathematical relationship in which the coefficients are of the order of unity". (i.e., $|k| < 10$ where $a = kB^j$, $j = 1$ or $j = 2$) Gilbert[5,7] and Jordan[2] advance Dirac's thesis and reconcile it with general relativity theory. Dirac, feeling a necessity to maintain the constancy of the Einsteinian **K**, postulated a change in the units of distance and time with time.[4] Dirac says simply that matter at a given point in space has a natural velocity which changes with time. Gilbert's scheme proposes different metrics for the description of electromagnetic and gravitational phenomena. Through this device he incorporated the Dirac hypothesis into relativeity theory. He found it necessary to postulate an age of approximately 4×10^9 years for the universe in order for his method to work. But neither this age nor Dirac's earlier estimate (7×10^8 years) causes any contradictions with other data. ~~This fact is so~~ because, according to these hypotheses, the rate of radioactive decay would be variable and decreasing with time (a problem Steiner considers as confounding attempts to extend correlation of geologic events with galactic ~~unity~~ processes earlier than the last cosmic year.) Jordan considers, in terms of his own relativistic interpretation of Dirac's principle, the consequence of an expanding universe and linearly decreasing K on earth processes. He goes so far as to posit that the earth has expanded from a time when there was a continuous sialic covering of the globe.

Dicke[3], elaborating Mach's principle and bringing it into a relativistic framework, concludes that G is as extremely small as it is only because the universe is as massive as it is. He also states that, there is only a limited time in the evolution of the universe during which the earth and physicists could exist, (because of the varying of constants). Therefore, he concludes that the coincidences on which Dirac based his theory are not as statistically significant as they at first appear. He feels that most of the large, dimensionless constants are themselves variable with time and not at rates which would maintain a given relationship between them. Dirac[6] rejects this idea on admittedly more aesthetic than scientific grounds, and says that to resolve the argument between the schools it would be necessary to measure the value of $\frac{GM_p^2}{\hbar c}$ which is approximately 5×10^{-39} to an accuracy of 1 in 10^{10}, and repeat the measurement in a few years to detect change.

My first question with respect to these data is about Steiner's finding of a decrease in G towards the galactic center. All the other theories referred to ~~to it,~~ (including the Dirac-Jordan effect which he uses as a fudge factor in data fitting) ~~and~~ postulate a direct relationship between average density of matter and G. All propose a decrease in G due to an expanding universe. How can he explain the finding of a decreased G towards the center of the galaxy, where it is known that the average density is far greater than toward the rim? Another thing I question is his method of determination of the G function. Although I don't understand exactly what he is doing, he seems to be plotting the G necessary to account for the discrepancy between the observed velocities of stars at given galactocentric distances and the velocities predicted for them by an inverse square law. However, the inverse square law does not apply to the attraction between a body and the center of a constant density array of bodies of which it is a part. Rather, the force increases linearly with distance from the center. In a body like the Milky Way, where the majority of the mass is in a central core, but where some mass is spread to great distances, one would expect a centripital force very similar to the obtained function of G. By the same reasoning that he used, the gravitational constant in the center of planets, stars, or any massive bodies, should be near zero. Although I think it must be admitted that Steiner has found some very strong relationships between geological events and the sun's galactic position, I would like a clearer demonstration of the reality of the gravitational function. The geological evidence for it almost seems stronger than the galactic.

My first impression of the maximal and minimal value of a G hypothesized by Steiner was that their difference could not be sufficient to cause the effects attributed to it. However, looking at the problem more closely, it becomes evident that it is enough. The difference between 6.67 and 7.0 is a little less than .05 of the total G. This increase is sufficient when it is taken to the tenth power to increase the solar constant by almost

60%. At Jordan's optimistic rate of change of earth radius with k (equation 2), the change in earth radius would be approximately .05 x 4000 miles = 20 miles, enough to submerge the entire continents several times over. Even at Dicke's more conservative rate (equation 1), the continents would sink about two miles.

Jordan proposes that the earth has expanded from a state having a continental-type crust. Assuming that the continents, including shelves, cover approximately one third of the earth's surface, the earth would have had to have an original radius of .57 its present value or ~2300 miles. By equation 2 this would require a G approximatley 1.75 times the present, or about 12.3. By equation 1, we would need ten times this figure! Even the lower value might be enough to turn Jupiter into a star.

In the midst of this confusion, I throw my hypothesis. G was higher in the past, high enough for some major phase changes and contractions. As G lowered with time, the earth suddenly hit a critical value for a major phase change, and the moon popped out of the Pacific !

to "cause" mountain building like or change in circuit [illegible]

For the purposes of this model it is assumed that the central galactic force law is an inverse square law with a varying gravitational "constant" G. According to Ogorodnikov, approximately 80% of the central galactic force $K(R)$ is given by

$$K(R) = \frac{G\ M_g}{R^2} \quad \text{(Ogorodnikov, 1965, equation 3·53, pp. 82-85; Trumpler \& Weaver, 1953)} \qquad (1)$$

where M_g is the mass of the galaxy (Table III) and R the galactocentric distance. On the basis of equation (1) the relationship

$$G = \frac{R\ V_c^2}{M_g} \qquad (2)$$

is given where V_c represents the empirical circular orbital velocity at the given galactocentric distance R, since $K(R)$ is also given by

$$K(R) = \frac{V_c^2}{R} \quad \text{(Ogorodnikov, 1965, equation 3·48, p. 82)} \qquad (3)$$

Equation (2) and Bok & Bok's somewhat out-of-date empirical data (Table II) permit the calculation of G as a function of R (Fig. 2).

Under the assumptions made, and owing to numerous necessary approximations and uncertainties*, only the general shape of this function may be considered valid, at best. The absolute value of G must be treated with caution. In Figure 2, G tends toward zero near the centre of the galaxy, rises to a maximum of approximately $7·0.10^{-8}$ c.g.s. units near its edge, and presumably tends toward zero at an infinite distance. This function

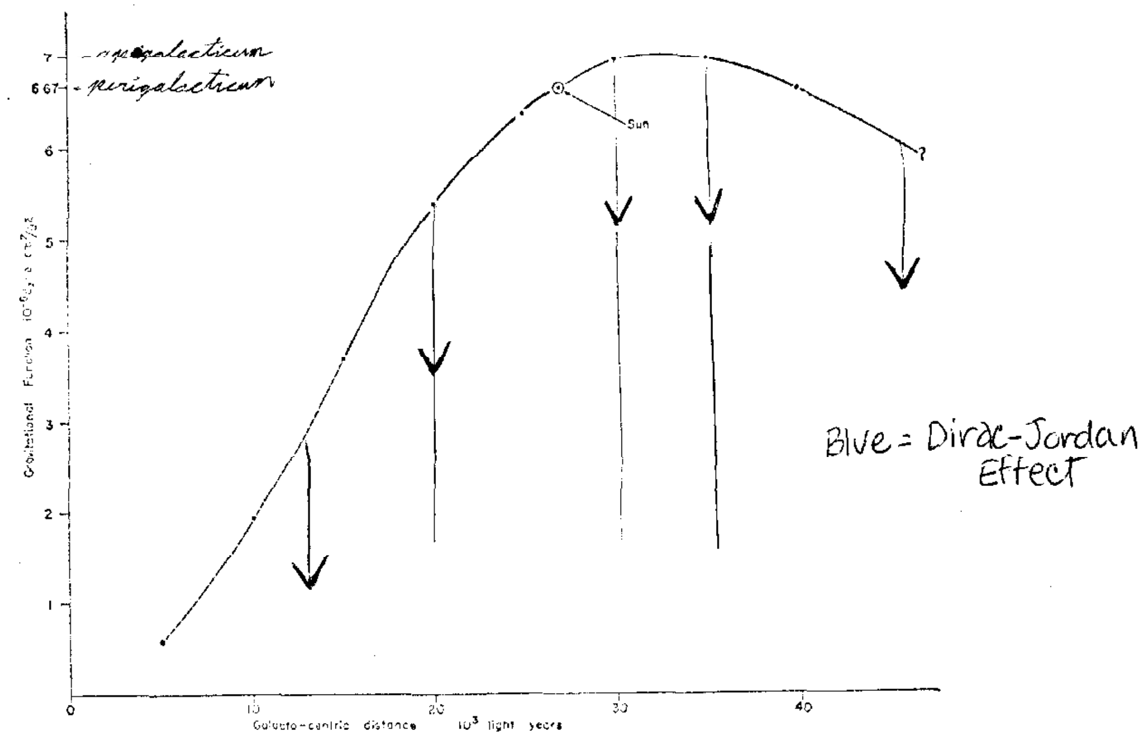


Fig. 2. An empirical gravitational function calculated on the basis of 1957 galactic data. Gravitational function in 10^{-8} dyne cm^2/g^2 which, at the present time, has the value of 6·67 c.g.s. units in the vicinity of the Sun. These calculations assume that the Newtonian "constant" of gravitation is a function of time and space, or a scalar field variable.

* The galactic orbits are calculated on the assumption of a constant G, but are utilised in a model employing a variable G. It needs to be assessed whether these calculations have to be revised and, if so, how does it change the variable G model and the comparison with geological phenomena.

into the Jurassic, depending on the quantitative estimates of the Dirac-Jordan Effect (Fig. 5 B, D). The pre-Permian part of the Hercynian cycle (middle Variscan) is correlative with the equivalent orbital path of the cosmic year before the present one (Fig. 5 B, C). Both of these cycles fall into the expanding phase. The post-Carboniferous part of the Hercynian cycle (late Variscan), falls into the contracting phase which is considerably shortened, owing to the probable Dirac-Jordan Effect (Fig. 5 B, C).

ICE AGES: *During the past 350 m.y. at least two periods of continental glaciation have been recorded:* the Pleistocene, starting about 1 m.y. ago; and the Carboniferous-Permian glaciation *centering around* 280 *m.y. ago.* Opdyke *(1962) states that the evidence for* the latter is unimpeachable in the Southern Hemisphere.

In comparing 1 m.y. and 280 m.y. with the galactic time-scale (Fig. 7 A, D) it is evident that these ice ages correspond closely to the perigalactical positions at approximately

In Blue: sketched linear Dirac-Jordan Effect and superimposed G rot Function

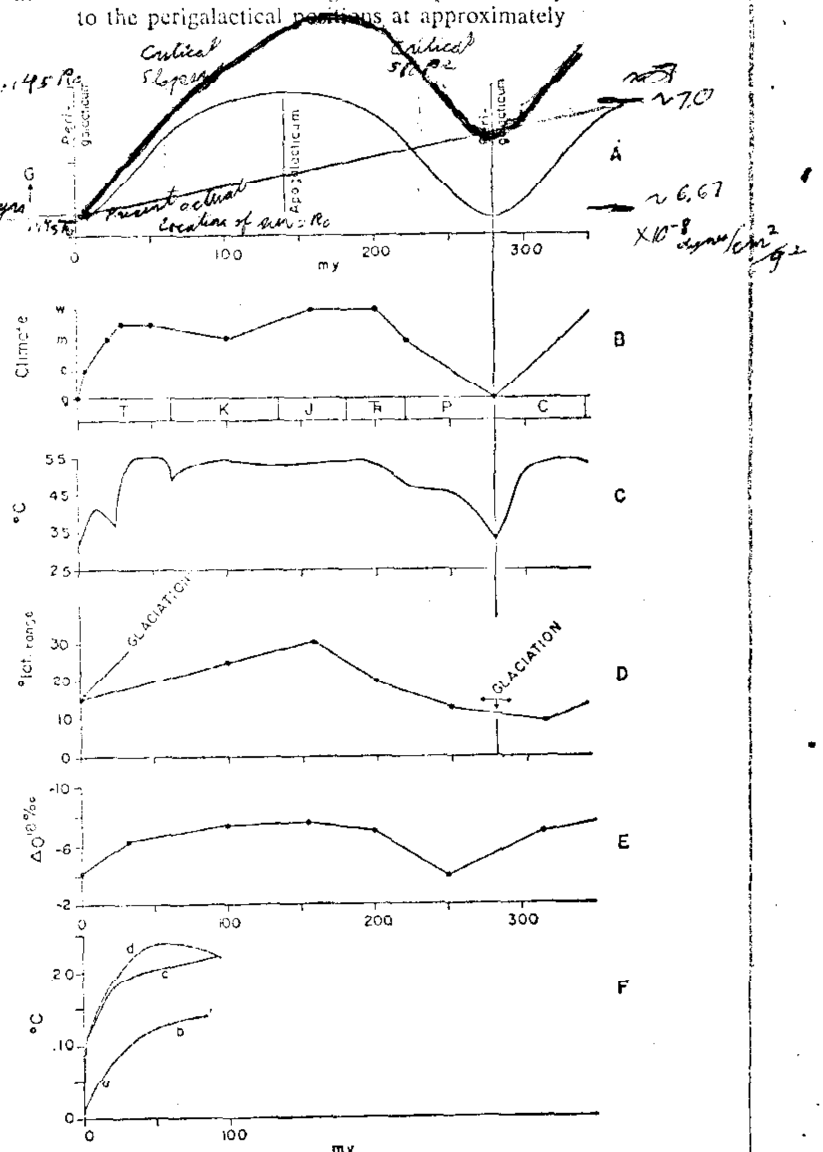


Fig. 7. *Palaeoclimatic Criteria.*

A. Variation of *G* according to simple galactic model (perigalactical passage approximated *to present time zero).*

B. Palaeoclimate after Brooks (1949)

w—warm and equable m—moderate
c—cool g—glacial.

C. Palaeoclimate after Dorf (1957) in terms *of mean temperature* (°C) 40° *to* 90° North latitude.

D. Palaeoclimatic zoning after Opdyke (1962) in terms of average ranges (degrees palaeolatitude) of tropical and subtropical climatic indicators with reference to the palaeoequator, as deduced from palaeomagnetic data.

E. Oxygen isotope ratios are thought to be temperature dependent and may thus represent a palaeoclimatic indicator. Data after Keith & Weber (1964). Average of mean freshwater and *marine ratios.*

F. *Cooling of oceans during Tertiary,* based on a variety of palaeoclimatic criteria after Holmes (1965, fig. 534). Some detail during Pleistocene (zero to 2 million years) has been omitted.

(a) Equatorial Pacific floor

(b) Alaska and Siberia sea floor

(c) *Central Europe*

(d) California.

"Later investigations show that the Atlantic and Indian Oceans shared a similar history *of gradual cooling*" (Holmes, 1965, p. 719).

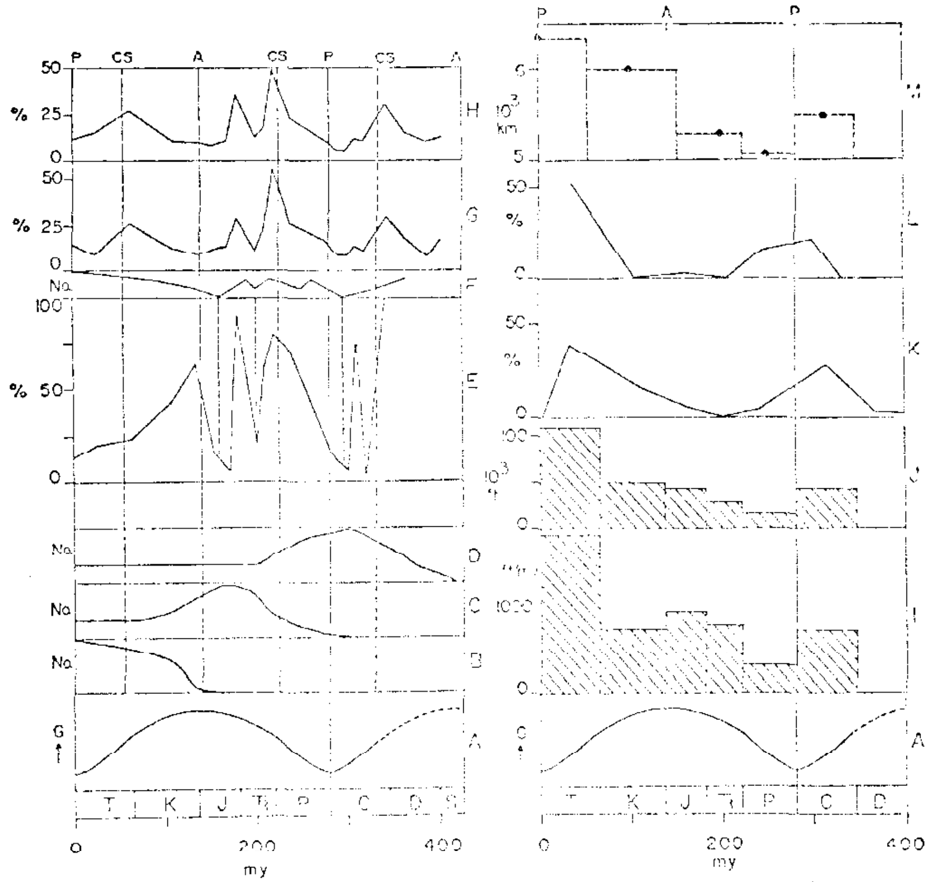


Fig. 8. A. Diagrammatic representation of the variation of *G* according to the simple galactic model
A—Apogalacticum P—Perigalacticum CS—Critical Slope
(perigalactical passage approximated to present time zero).

B to D. Census of the three major groups of terrestrial floras based primarily on families and secondarily on genera, taken from Dorf (1955).
Relative scale is the same in C and D. Scale of B has been reduced by a factor of five relative to C and D.

B. Relative abundance of angiosperms (flowering plants: most trees and woody shrubs, grasses, herbs, etc.).

C. Relative abundance of gymnosperms (naked seed plants: seed ferns, cycadoids and cycads, Cordaitales, Ginkgoales and conifers).

D. Relative abundance of pteridophytes (early vascular plants: Psilopsida, club mosses, horsetails, rushes, ferns).

E. Family extinction curve of "terrestrial" fauna (amphibians, reptiles, mammals) taken from Newell (1963).
Note that some of the minima of F coincide with minima of E. This may be interpreted as less extreme vertebrate extinction minima (E) when they coincide with collection locality minima (F). This consideration leads to the conclusion that terrestrial faunal extinctions were much more frequent during the contracting phase from the perigalacticum at 280 m.y. to the apogalacticum at 140 m.y. than during the expanding phase from 140 m.y. to the present perigalacticum. This is in general agreement with the consequences of the simple galactic model, since a tendency toward a restriction of terrestrial environmental niches may be expected during the contracting phase, while during the expanding phase progressively more terrestrial environmental niches should become available. Note

zero and 280 m.y., which implies a minimum G and minimum solar radiation (Equation 5A). In this simplified model for the past 350 m.y., G changes from decreasing to increasing only at the perigalacticum, but if one visualises random or systematic gravitational effects of more local origin, it is conceivable that G may vary through several cycles of decreasing and increasing trends of small amplitude and period in the vicinity of the perigalactical position or, for that matter, anywhere along the Sun's orbit. In addition, the oscillations of Öpik's solar model may be important near the perigalactical positions.

In view of the fact that most climatologists now tend to favour a changed solar constant as the trigger mechanism for ice ages (Shapley, 1953), the above comparison seems encouraging, since it may offer an opportunity to decide between Simpson's (1938) and subsequent arguments (owing to atmospheric effects glaciation occurs when the solar constant increases) and the point of view of the proponents of the "ice age with low solar constant" (Bell, 1953).

In regard to astronomical theories concerning ice ages, it should be noted that a changing G not only necessitates a changed heliocentric mean-orbital radius of the Earth, but might affect other *Orbital Elements* (eccentricity, ecliptic, etc) as well, such as postulated by Milankovitch (1938*a, b*). The mechanism implied by this comparison promises to satisfy all requirements for the explanation of ice ages, as stipulated by Coleman (1926) and Charlesworth (1957).

OTHER PALAEOCLIMATIC CRITERIA: Since the solar constant may be regarded as directly proportional to the gravitational "constant" (Equation 5a), palaeoclimatic indicators should be directly comparable with the galactic time-scale (Fig. 4).

Since most palaeoclimatic data are available only in terms of geological periods, maxima and minima may be compared. A number of fairly independent categories of palaeoclimatic indicators are now available (Nairn, 1961; Schwarzbach, 1950), all of which imply a low solar constant near the perigalactical position and a long-lasting, high solar constant centering around the apogalacticum, as the galactic model demands for the past 350 m.y. In particular, there are Brooks's qualitative data (1949) showing well-defined minima in the Pleistocene and at the Carboniferous-Permian boundary, while the maximum ranges from mid-Triassic to mid-Tertiary (Fig. 7 A, B). Dorf's (1957) curve, which is based on palaeobotanical evidence, and is expressed in terms of mean-temperature in degrees Celsius 40° to 90° North latitude, is essentially the same as Brooks's curve, with the exception of some minor superimposed oscillatory changes (Fig. 7 A, C).

Opdyke (1962), in attempting to find systematic changes of climatic zoning of the

Fig. 8 (*continued*)

also that the terrestrial faunal extinction peaks (E) at Mid-Carboniferous and at the Jurassic-Triassic boundary are much more severe than the equivalent marine faunal extinctions. Since the terrestrial fauna is more severely affected than the marine, primarily climatic causes for these two extinctions are more likely.

F. Approximate number of principle vertebrate collecting localities simplified after Gregory (1955). F is included here since Gregory (1955) has shown that abundance, and presumably extinction, arguments in regard to vertebrates, are not independent of the limited number of known vertebrate collecting localities.

G. Family extinction curve of "marine" fauna taken from Newell (1963) (corals, brachiopods, crinoids, ostracods, trilobites, ammonoids, archaeogastropods, sponges, forams, polyzoans, echinoids and conodonts).

H. All-inclusive faunal extinction curve based on families after Newell (1963). (Includes groups listed under E and G *plus* fishes.)

I. Maximal rates of geosynclinal sedimentation calculated from Holmes's (1960) data (J) on the basis of the Follnsbee (1960) time-scale. Note pronounced break at Permian-Carboniferous boundary. Rate of sedimentation is thought to be roughly proportional to rate of subsidence. The superimposed minor maximum during the Jurassic is interpreted as a result of the interaction of rate of subsidence and depth of water. Near the apogalacticum maximum depth of water may be expected from the simple galactic model. The Dirac-Jordan Effect would tend to shift such a maximum depth of water into the Jurassic.

J. Maximal sediment thickness (world maxima) after Holmes (1960).

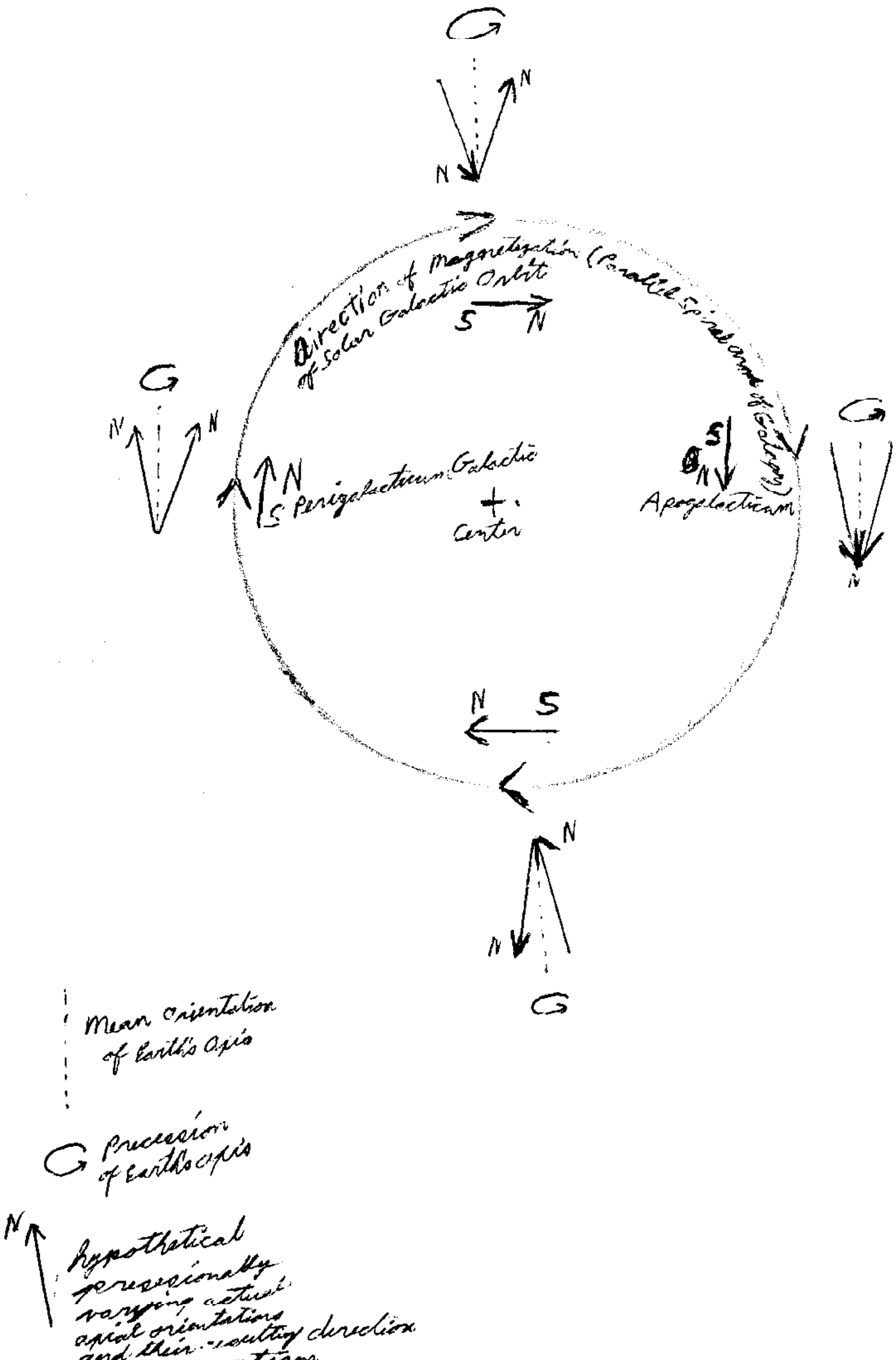
K. World's petroleum deposits after Gubkin published by Belousov (1962).

L. World's coal reserves after Stepanov published by Belousov (1962).

M. Estimates of the radius of the Earth on the basis of palaeomagnetic data after Van Hilten (1963). Note break of trend at the perigalacticum equivalent to the Permian-Carboniferous boundary.

Figure 9

(adapted from Steiner, 1967)



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