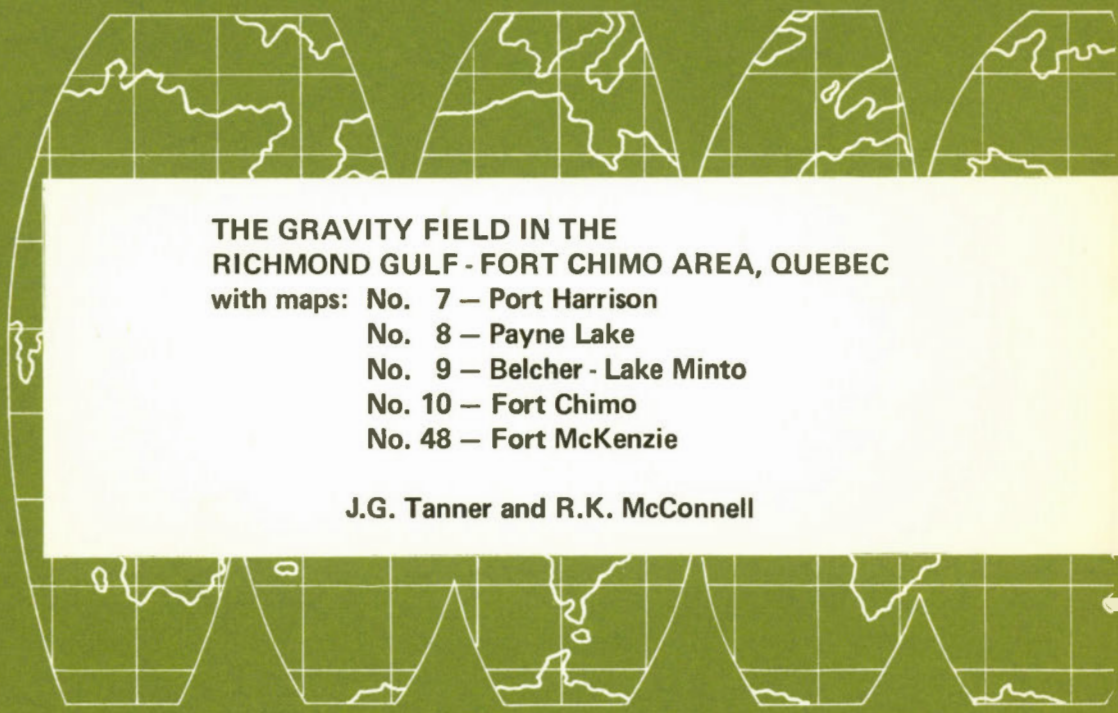
gravity map series of the earth physics branch



THE GRAVITY FIELD IN THE RICHMOND GULF - FORT CHIMO AREA, QUEBEC

with maps: No. 7 — Port Harrison
No. 8 — Payne Lake
No. 9 — Belcher - Lake Minto
No. 10 — Fort Chimo
No. 48 — Fort McKenzie

J.G. Tanner and R.K. McConnell

DEPARTMENT OF ENERGY, MINES AND RESOURCES
OTTAWA, CANADA 1970

GRAVITY MAP SERIES

of the

DOMINION OBSERVATORY

Ottawa

THE GRAVITY FIELD

in the

RICHMOND GULF - FORT

CHIMO AREA, QUEBEC

No. 7 - Port Harrison

No. 8 - Payne Lake

No. 9 - Belcher-Lake Minto

No. 10 - Fort Chimo

No. 48 - Fort McKenzie

J. G. Tanner and

R. K. McConnell

Canada

Department of Energy, Mines and Resources

Observatories Branch

1970

CONTENTS

THE GRAVITY FIELD IN THE RICHMOND GULF - FORT CHIMO AREA, QUEBEC

J. G. Tanner and R. K. McConnell

ABSTRACT - During the years 1959, 1960, 1961 and 1965 the Dominion Observatory observed some 1500 stations in northern Quebec west of 68°W and between latitudes 56°N and 60°N. Analysis of these measurements, together with observations taken in adjacent regions of northern Quebec, suggests that the Bouguer anomalies have a relative accuracy of ±2 mgal.

Comparison of the Bouguer anomaly field with geology suggests that: (a) local and regional variations of Bouguer anomaly within the Superior Province can be correlated with occurrences of high-grade metamorphic rocks (granulites), and (b) the linear negative anomaly over the Labrador Trough is most likely caused by deep-seated structure.

RÉSUMÉ - Au cours des années 1959, 1960, 1961 et 1965 l'Observatoire fédéral a procédé à des observations à quelque 1500 stations dans le nord du Québec, à l'ouest du 68^{e} degré de longitude et entre les 56^{e} et 60^{e} degrés de latitude nord. Les analyses de ces mesures, jointes à des observations effectuées dans des régions adjacentes du nord du Québec, indiquent que les anomalies de Bouguer présentent une précision relative de ±2 mgal.

La comparaison entre le champ des anomalies et la géologie indique: (a) que des variations locales et régionales des anomalies de Bouguer dans la province Supérieure peuvent être rattachées à l'existence de roches fortement métamorphisées (granulites), et (b) que l'anomalie linéaire négative du géosynclinal du Labrador résulte probablement d'une structure en profondeur.

INTRODUCTION

The gravity data presented here result from field programs carried out by the Dominion Observatory during the years 1959, 1960, 1961 and 1965 in the area shown in Figure 1. Float-equipped, fixed-wing aircraft were used for transportation to take advantage of the extensive network of lakes and rivers in the area. The 1500 observations are spaced at intervals of 10 to 15 km.

Most of the area of Figure 1 is gently undulating and devoid of systematic topographic lineaments. The exception is the Labrador Trough to the east where pronounced north-south lineaments, controlled by geological structure, are present. The southern half of the map area is tree covered; the northern half is barren.

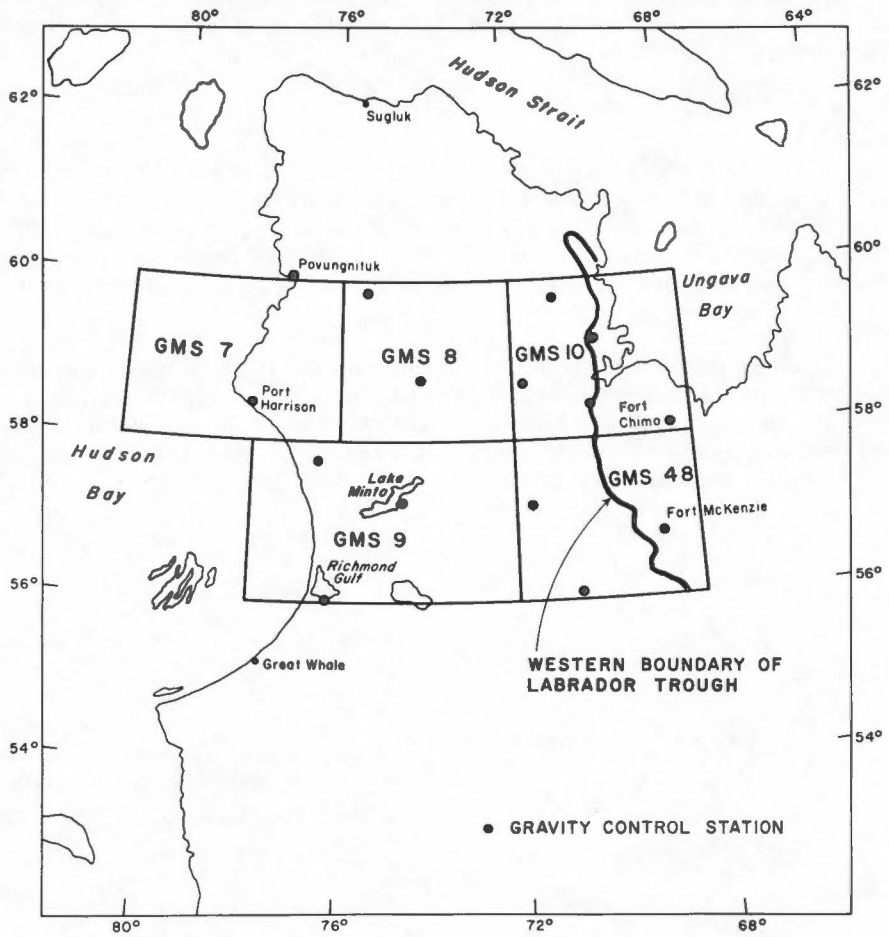


Figure 1. Location map showing areas covered by gravity maps, approximate locations of gravity control stations and the major geographic features of northern Quebec.

In the remainder of this report the measurements and their interpretation will be discussed. This discussion is a summary of part of a comprehensive analysis recently completed by Tanner (1969).

SUMMARY OF MEASUREMENTS

The gravity measurements were made using quartz-fabricated Worden gravimeters. Standard observing procedures were adopted to make the gravity measurements; a control network of base-looped stations at 100 km intervals was first established and then used as a reference for the regional gravity traverses. At each station, the observers also read two Wallace and Tiernan altimeters and recorded the wet and dry bulb temperature. Wherever possible rock samples were taken for density determinations.

Details of the above procedures and the reduction of the data to Bouguer anomalies are given elsewhere (Tanner and Buck, 1964; Tanner, 1969).

The accuracy of the Bouguer anomalies has been discussed extensively by Tanner and McConnell (1964) and Weaver (1967), and the reader is referred to these publications for details of the estimated errors. In this area the relative accuracy of the Bouguer anomalies is estimated to be ± 2 mgal. By far the greatest contribution to this estimated error is the uncertainty in the elevation of the stations, which causes an error in excess of one milligal.

GENERAL DESCRIPTION OF THE GRAVITY FIELD

The gravity maps (see also Figure 2) accompanying this report show that the Bouguer anomaly is almost entirely negative. A small isolated area of positive Bouguer anomaly occurs in the northwestern part of the area (G.M.S. No. 7). The total range of anomaly is large; it varies from a minimum of about -100 mgal over the Labrador Trough to a maximum of about 5 mgal at 56° 45'N, 72° 22''W.

Comparison of the average value of the Bouguer anomaly (-50 mgal) with that expected, on the assumption that the topography has the form of an infinite sheet 750 feet thick, indicates that the region is overcompensated by about 25 mgal. Innes and Argun Weston (1966) have pointed out that this overcompensation can be explained on the basis of incomplete isostatic recovery in the Hudson Bay area subsequent to deglaciation.

The dominant feature on the gravity maps is the north-south trending Bouguer anomaly over the Labrador Trough. This anomaly consists of a broad zone of relatively low gravity anomaly containing two locally positive anomalies. These latter anomalies are located near the axis of the gravity low and rise some 40 mgal above minimum values of the low.

Within the Superior Province to the west of the Labrador Trough there are no prominent linear anomalies, although the gravity field is unusually variable for the Superior Province in Quebec. From south to north the anomaly field over the Superior

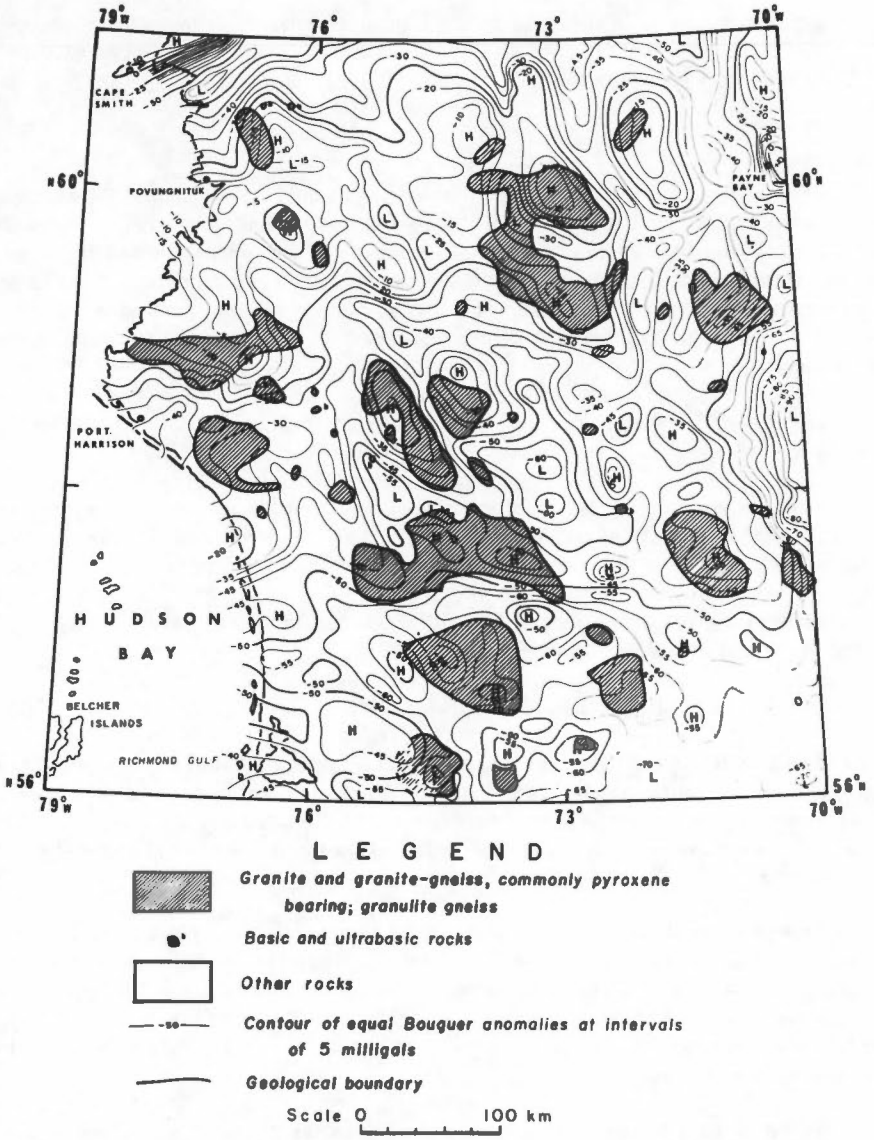


Figure 2. The relationship of the Bouguer anomaly field to occurrences of granulite in northwestern Quebec. The gravity units are milligals.

Province rises irregularly from a level of about -60 mgal along the southern border of the area to a level of about zero anomaly along the northern border. These high gravity values occur along a broad axis which trends slightly north of east and continues to the north of the area discussed in this report.

GENERAL GEOLOGY

Both Archaean and Proterozoic rocks occur within the area (Figure 3). The younger Proterozoic rocks outcrop in and to the east of the Labrador Trough and along the shore of Hudson Bay near Richmond Gulf. The remainder, and by far the largest part, of the area is underlain by the Archaean rocks of Superior Province. Geological descriptions of the Archaean rocks have been given by Kretz (1960), Stevenson (1965) and Eade, et al. (1966). The last reference presents the results of a geochemical study of the rocks of the Superior Province. The Proterozoic rocks are discussed by Bergeron (1957) and Fahrig (1957).

The rocks exposed within the Superior Province consist mainly of granites, granitic gneisses and granulites with minor occurrences of basic and ultrabasic intrusive rocks. The granitic gneisses and the granites underlie most of the area and separate areas in which banding of the rocks is respectively more or less pronounced. The granulites also outcrop extensively. Eade, et al. (1966) have referred to this region as the largest area of granulites known in the world. These rocks, which are in the lower part of the granulite facies, have a yellowish green, greasy lustre. The basic and ultrabasic rocks occur as small plugs throughout the area.

Of the Proterozoic rocks only those in the Labrador Trough and to the east of the Labrador Trough are discussed here. The Labrador Trough is a fold belt, some 800 km in length, consisting of a western sedimentary section and an eastern basic igneous section. The total width of both sections is about 80 km. The western boundary of the Labrador Trough with the Superior Province is mainly unconformable, but faults are present in places. To the east, the Labrador Trough is separated from a metamorphic complex of schists and gneisses, much of which maybe in the granulite facies of metamorphism (F. C. Taylor, Geological Survey of Canada, personal communication), by a zone of thrust faulting. Fahrig (1957) and Bergeron (1957) point out that the change from lower-grade metamorphic rocks to the west, to the higher-grade rocks to the east, takes place in the vicinity of the zone of thrusting and is continuous across it.

The Archaean rocks were last folded about 2500 my ago and this event may have produced the granulite facies of metamorphism. The Labrador Trough began to develop in excess of 2000 my ago (Beall, et al., 1963) and continued to be active tectonically up to about 1400 my ago. The major orogeny appears to have taken place about 1600 my ago.

The structural trends, both within the Superior Province and the Churchill Province, are north-south. The trend in this northern part of Superior Province differs substantially from the east-west trend normally observed in the Superior Province to the south.

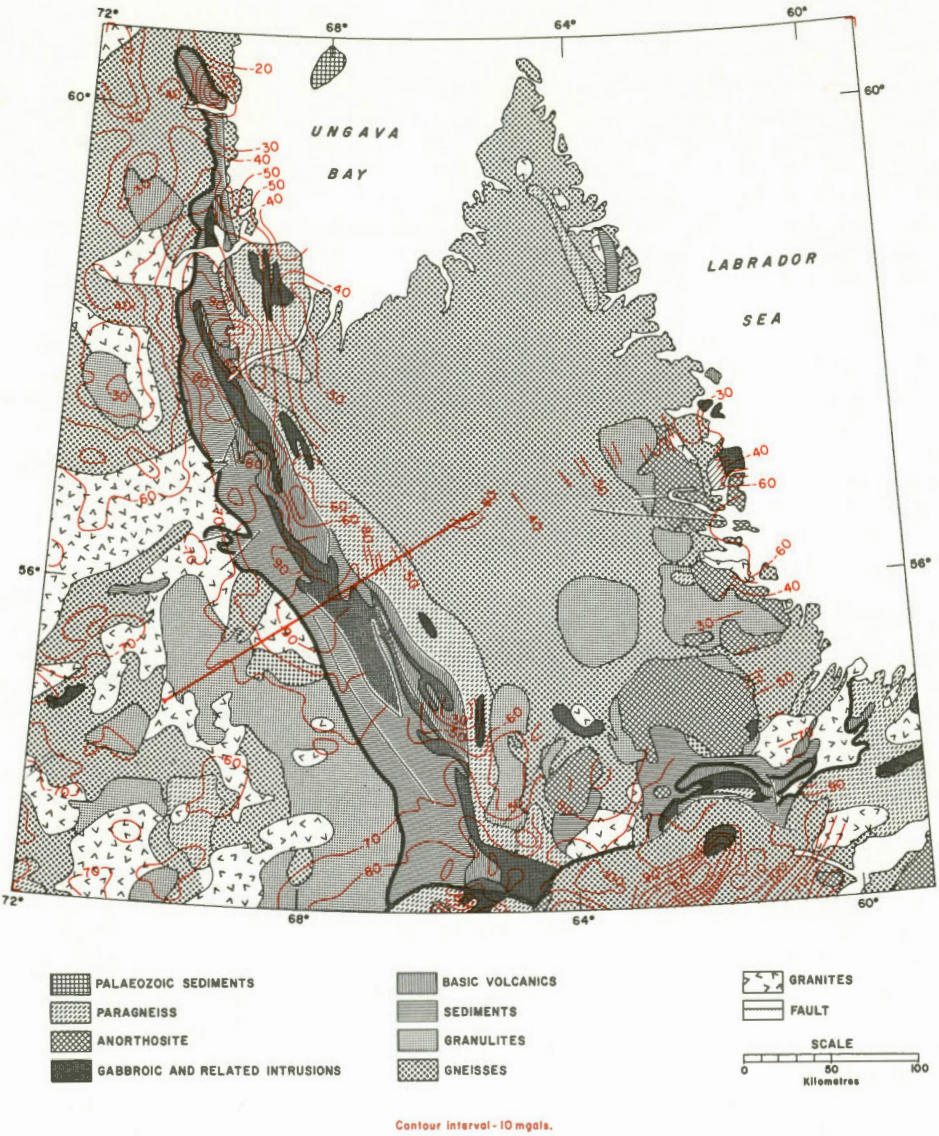


Figure 3. The geology (black) and gravity (red) of the Labrador Trough region. The gravity units are milligals. The geology has been compiled from maps of the Geological Survey of Canada and the Quebec Department of Mines.

CORRELATION OF GEOLOGY AND GRAVITY

This section is a summary of some of the results given by Tanner (1969). The main features of the gravity field are:

(a) the unusually variable anomaly field in the Superior Province,

(b) the high average level of the Bouguer anomaly in this northern part of the Superior Province, and

(c) the linear negative anomaly over the Labrador Trough.

The explanation of the higher level of anomaly and the more irregular anomalies in this northern part of the Superior Province can be made on the basis of the granulites exposed in the region. Figure 2 shows the distribution of gravity in relation to the distribution of granulites and it can be seen that the correlation between locally high gravity anomalies and the occurrence of granulites is excellent. Although there are no density measurements to indicate a high density for the granulites, this correlation is reasonable theoretically because the granulite facies metamorphism involves temperatures which lead to the removal of water and alkalis and, therefore, probably to a rock of increased density. Identification of granulites as the source of the regionally high gravity values may mean that there is either a 'layer' of granulites present locally within this northern part of the Superior Province or a universal 'layer' of granulites is more elevated in this region than elsewhere. Gravity data alone will not resolve this problem and more geological and geophysical work is necessary before the question of a 'granulite layer' in the region can be resolved.

The interpretation of the Labrador Trough negative anomaly is hampered because there are very few gravity observations to the east of the Trough. However, it would seem unlikely that the rocks of the Labrador Trough cause the negative anomaly for three reasons:

1. There is a considerable volume of basic igneous rock in the Labrador Trough.

2. The western contact of the rocks of the Labrador Trough, which dip gently eastward, lies along the axis of the negative anomaly in the north near Fort Chimo (Figure 3).

3. The rocks of the Labrador Trough extend to the north and south of the negative anomaly (Figure 3).

Granites appear unlikely to be a cause of the negative anomaly because there is no evidence from the surface geology that they are sufficiently abundant in the region.

Tanner (1969) has pointed out that the anomaly can be explained as an edge effect between two continental blocks in isostatic equilibrium. This interpretation

requires that the crust to the east of the Labrador Trough be thicker and more basic than that under the Superior Province. The hypothesis is consistent with the results of recent seismic and gravity investigations (Weaver, 1967) but does ignore the possibility of lateral density variations in the upper mantle. In the absence of direct evidence for density variations in the upper mantle, their inclusion in the interpretation is an unnecessary complication. However, it is believed that the hypothesis could be readily extended to include the upper mantle in the interpretation.

The local positive anomalies within the regional negative anomaly of the Labrador Trough occur over the eastern basic igneous part of the structure. The fact that these anomalies are not continuous suggests that, if the basic igneous rocks of the Labrador Trough are the cause of the anomaly, the thickness of these rocks varies considerably along the length of the Labrador Trough. It is possible that, as in the far northern part of the Labrador Trough (Tanner and McConnell, 1964) these locally positive anomalies are caused by large basic intrusions.

REFERENCES

Beall, G.H., P.M. Hurley, H.W. Fairburn, and W.H. Pinson, Jr., 1963. Comparison of K-Ar and whole rock Rb-Sr dating in New Quebec and Labrador, Am. J. Sci., 261: 571-580.

Bergeron, Robert, 1957. Proterozoic rocks of the northern part of the Labrador geosyncline, the Cape Smith Belt and the Richmond Gulf area, The Proterozoic in Canada, Roy. Soc. Can. Spec. Pub. No. 2: 101-111.

Eade, K.E., W.F. Fahrig, and J.A. Maxwell, 1966. Composition of crystalline shield rocks and fractionating effects of regional metamorphism, Nature, 211: 1245-1249.

Fahrig, W.F., 1957. Geology of certain Proterozoic rocks in Quebec and Labrador, The Proterozoic in Canada, Roy. Soc. Can. Spec. Pub. No. 2: 112-123.

Innes, M.J.S., and Argun Weston, 1966. Crustal uplift of the Canadian Shield and its relation to the gravity field. Annales Acad. Sci. Fenn., AIII 90: 169-176.

Kretz, R., 1960. Geological observations in northern New Quebec, Geol. Surv. Can., Paper 60-12.

Stevenson, I.M., 1965. Leaf River map area, New Quebec and District of Keewatin, Geol. Surv. Can., Paper 64-28.

Tanner, J.G., and R.J. Buck, 1964. A computer oriented system for the reduction of gravity data. Pub. Dom. Obs., XXXI: 53-65.

Tanner, J.G., and R.K. McConnell, 1964. The gravity anomaly field in the Ungava region of northern Quebec with maps. Gravity Map Series Dom. Obs., Nos. 4-5.

Tanner, J.G., 1969. A geophysical interpretation of structural boundaries in the eastern Canadian Shield. Unpublished Ph.D. thesis, Univ. of Durham.

Weaver, D.F., 1967. A geological interpretation of the Bouguer anomaly field of Newfoundland. Pub. Dom. Obs., XXXV: 209-251.