INTERPRETATION OF GRAVITY ANOMALIES OVER SRI LANKA AND ADJACENT AREAS AND COMPUTATION OF THE LOCAL GEOID OF SRI LANKA

BY

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The work described in this thesis was carried out by me under the supervision of Professor D.A. Tantrigoda and a report on this has not been submitted to any University for another degree.

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P.Geekiyanage.

I certify that the above statement made by the candidate is true and that this thesis is suitable for submission to the University for the purpose of evaluation.

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Professor D.A.Tantrigoda,
Supervisor.

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ABSTRACT

The Bouguer gravity anomalies over Sri Lanka and south India and free air anomalies over nearby Indian oceanic regions covering an area of approximately 600 km x 600 km have been digitized at 0.5^0 intervals and interpreted using an iterative technique. Results of this interpretation mainly show that the average crustal thickness beneath south India is 40 km and that beneath Sri Lanka is 35 km.

A detailed three-dimensional interpretation of Bouguer gravity anomalies over Sri Lanka, which have been sampled at 0.125^0 intervals has been carried out assuming that the entire crustal structure of the island has a constant density. Results show that the average crustal thickness of Sri Lanka is 31.3 km with a maximum of 37 km.

The contact boundary between two major lithological units of Sri Lanka known as the Highland Complex and the Vijayan Complex is one of the most striking features of geology of Sri Lanka. An interpretation of Bouguer gravity anomalies has been carried out to produce a detailed three-dimensional model for the crustal structure beneath this boundary as well as the central highlands of the country assuming the Highland and the Vijayan Complexes of rocks have two different densities. Further, it has been assumed in this study that the Highland Complex is underlain by the Vijayan Complex which acts as a tectonic basement to the Highland Complex. Results show that the maximum thickness of the Highland Complex is 7 km and the maximum thickness of the crust over this region is 36 km. The crustal thickness is comparatively higher beneath the central highlands and beneath the boundary between the Highland and the Vijayan rock units indicating the presence of a crustal root. A study of the

isostatic equilibrium of this region has also been carried out and found that the region is more or less in the equilibrium.

In addition to the interpretation of gravity anomalies over Sri Lanka and nearby regions, relative and absolute geoids of Sri Lanka have also been computed in this study. Relative geoid of Sri Lanka consists of both negative and positive heights reaching a maximum of 1.1 m and a minimum of -0.9 m. The positive component spreads over the entire central highlands and extends towards the eastern coast of the island. The absolute geoid of Sri Lanka has been calculated by superimposing the relative geoid on the global geoid calculated form the EGM96 geopotential model. The absolute geoid of Sri Lanka is entirely negative having a maximum of -91.5 m located over the central highlands of the country.

CHAPTER 1

INTRODUCTION AND GEOLOGICAL SETTING OF SRI LANKA

Sri Lanka (formerly Ceylon) is an island situated in the Indian ocean close to the southern part of Indian sub-continent, having the latitude range of 5.875^0 - 9.825^0 N and the longitude range of 79.750^0 - 81.875^0 E (Figure 1.1). The total area of the island is about 65525 km^2 and its length and breadth are 432 km and 224 km respectively (Vitanage, 1988). The physiography of Sri Lanka can be described briefly as consisting of a central mountain mass (central highlands) rising in a series of ramparts from a low flat land which is extending into the sea (Figure 1.2). The central highlands forms a complex physiographical pattern with mountain chains, massifs, slopes and basins. The maximum topographic height of the central highlands is 2485 m observed at Pidurutalaga (Figure 1.2). The overall physiography can be generalized to represent three peneplaines, one rising above the other.

Almost 90% of Sri Lanka is underlain by crystalline, non-fossiliferous metamorphic rocks belonging to Precambrian age (Cooray, 1984; Cordani and Cooray, 1989; Kroner et al., 1991; Voll and Kleinschrodt, 1991; Cooray, 1994). These metamorphic rocks can be divided into four lithotectonic complexes known as Highland Complex, Vijayan Complex, Wanni Complex and Kadugannawa Complex as shown in Figure 1.3 (Kroner et al. 1991; Voll and Kleinschrodt, 1991; Cooray, 1994). The rest of the island is mainly covered by sedimentary rocks of various ages. Miocene limestone is the major sedimentary rock type found in Sri Lanka (Figure 1.3). Other sedimentary rock formations belong to Jurassic, Pleistocene and Holocene ages. In addition, igneous intrusions can also be seen scattered throughout the island.

The relative ages of the metamorphic units mentioned above have been a controversy in the geology of Sri Lanka. Adams (1929), Coates (1935), Wadia (1943) and Fernando (1948 a and 1948 b) believed that the Vijayan Complex was the basement on which the Highland

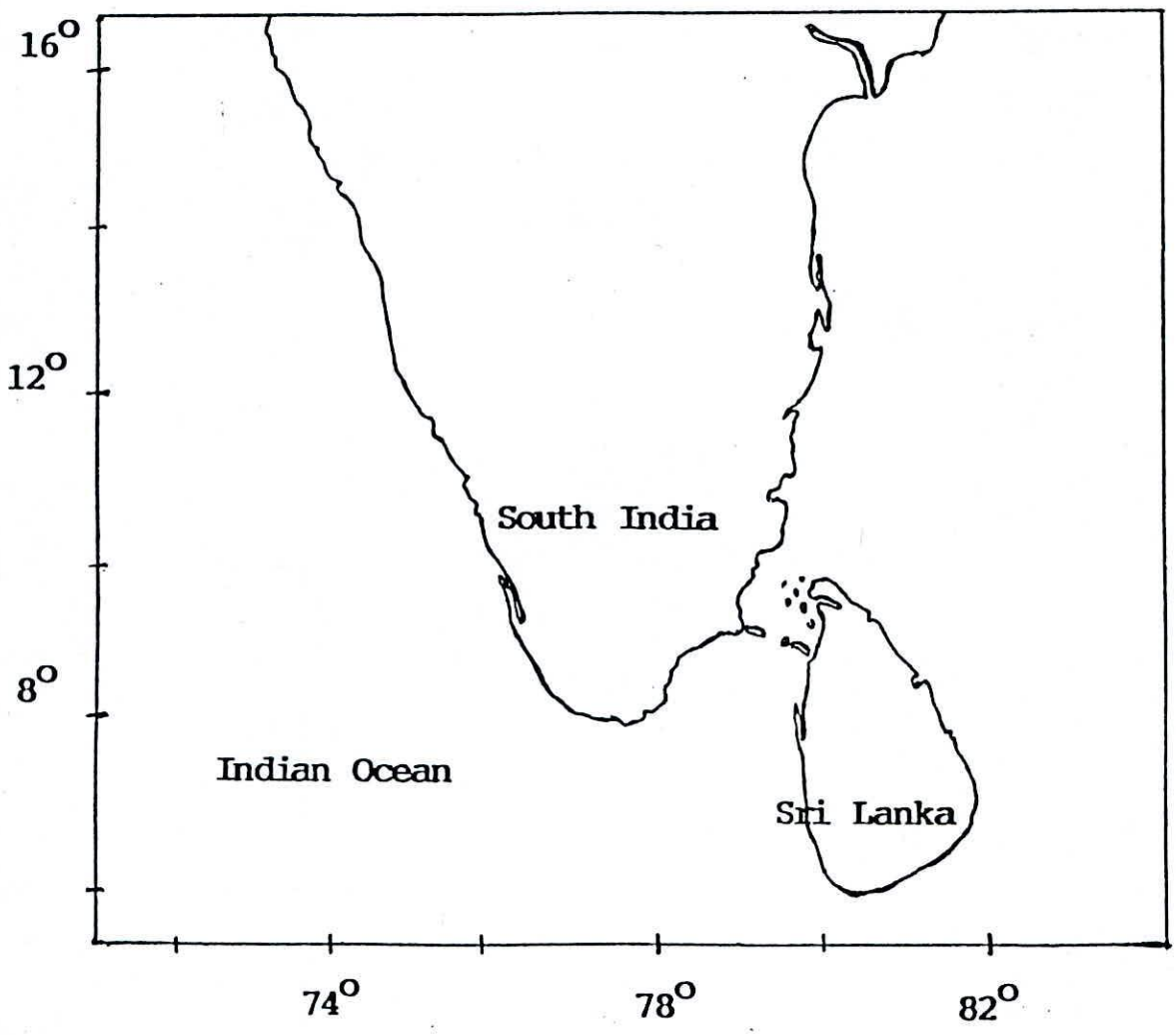

Figure 1.1 Position of Sri Lanka in the Indian ocean.

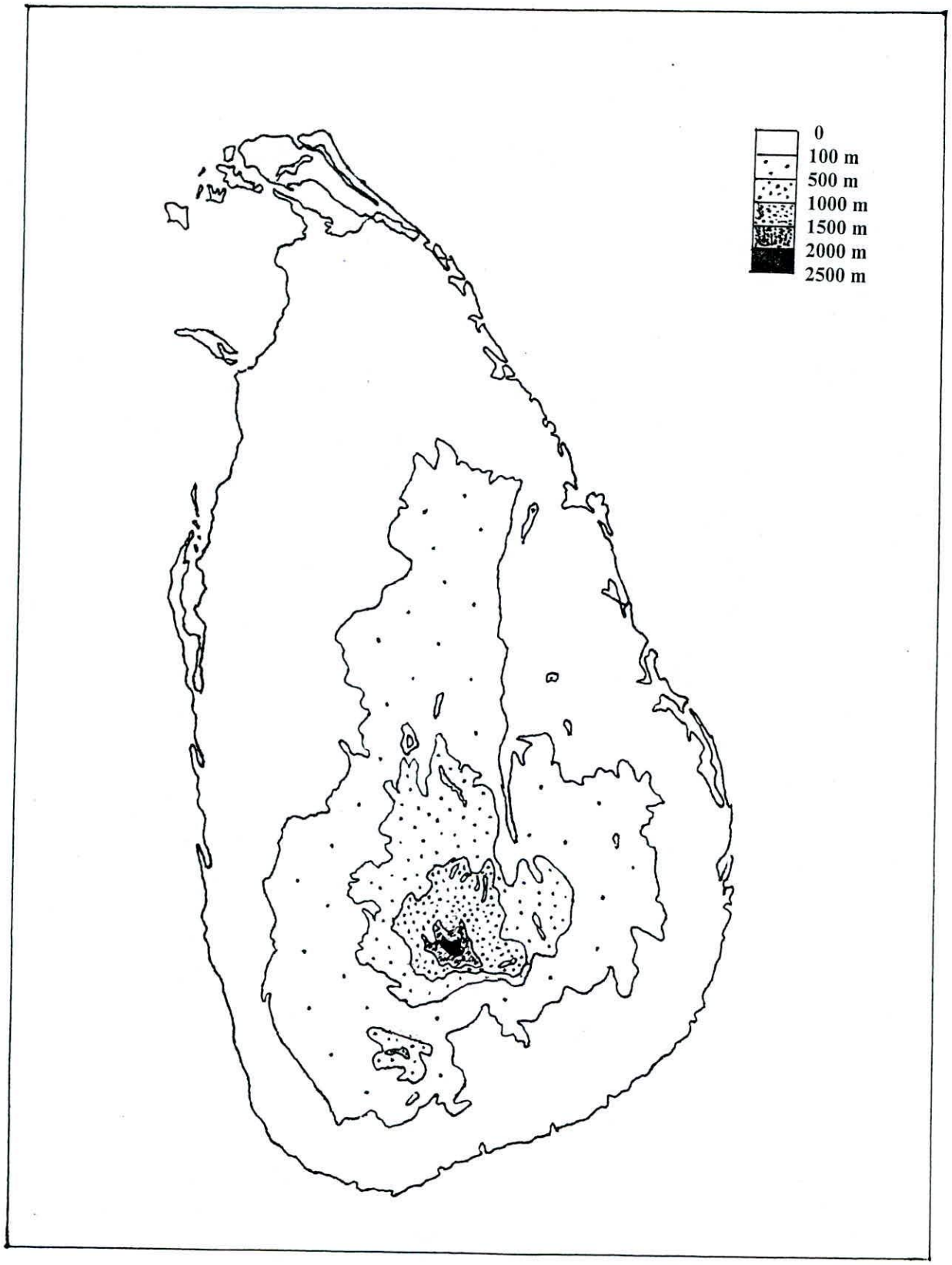

Figure 1.2 Simplified Topographic map of Sri Lanka

Complex of rocks have been deposited. Katz (1971), Munasinghe and Dissanayake (1979, 1980 a and 1980 b) too believed that the Highland Complex of sediments had been deposited on an earlier Vijayan basement. Vitanage (1959, 1970 and 1972) has held a view opposite to this. According to Berger (1973), Berger and Jayasinghe (1976) and Cooray (1978), the Vijayan Complex of rocks had been formed by retrogressive metamophism of the pre-existing Highland Complex of rocks. Crawford and Oliver (1969) analyzed rock samples using radiometric age dating techniques and concluded that the age of the Highland Complex is more than 2.20 Ga and that of the Vijayan Complex is about 1.00 Ga. According to Kroner (1991) and Voll and Kleinschrodt (1991), the depositional age of Highland Complex of rocks varies from 1.85 Ga to 2.30 Ga while that of Vijayan Complex of rocks ranges from 1.02 Ga to 1.10 Ga. Recently, Cooray (1994) pointed out that the Highland Complex is the oldest unit in which metasediments of Palaeoproterozoic age were intruded by granitoids 1.8 -1.9 Ga ago.

The Highland Complex (previous Highland Series and Southwestern Group) occupies mainly the central highlands as well as the southwestern part of the island and extends as a wide belt of granulite facies rocks from the northeastern coast to the southern coast (Figure 1.3). In addition, outliers of the Highland Complex of rocks are found within the Vijayan Complex at Kataragama, Maligawila and along the Kudaoya river as shown in Figure 1.3 (Fernando, 1970; Hapuarachchi, 1982; Somasekaram, 1988; Cooray, 1984; 1994). The outcrop of contact between the Highland Complex and the Vijayan Complex is very distinct and features such as hot water springs, serpentinite intrusions and mineralization zones can be observed along this boundary (Jayawardene and Padmasiri, 1977; Dissanayake and Van Riel, 1978 a: 1978 b; Munasinghe and Dissanayake, 1980 a; 1980 b; Jayewardena, 1982; Dissanayake, 1982; 1984 and 1985; Cooray, 1984). More recently, several workers suggested that the boundary between the Highland and Vijayan Complexes is a tectonic one. Munasinghe and Dissanayake (1979 and 1980 b) suggested that this boundary is a convergent plate margin while Jayawardena (1982) postulated that this boundary is a cretaceous rift zone, which closed at a later period. Another

speculative view held by Munasinghe and Dissanayake (1982) is that it is a collision zone between two mini plates. A view now generally accepted is that the Highland - Vijayan boundary is a sub-horizontal thrust contact (Vitanage, 1985; Krõner, 1986; Kleinschrodt, 1994). Marked differences in rock composition, metamorphic grade, age and isotopic characteristics between the Highland and Vijayan Complexes suggest that this thrust contact may be a boundary between two crustal provinces (terranes) that may have collided during the Pan-African orogeny in the latest Precambrian (Milisenda et al., 1988, Krõner, 1991). However, the boundary between the Highland and Wanni Complexes is diffuse and little is known about its nature (Cooray, 1984; 1994).

The Highland Complex consists mainly of supracrustal rocks (marbles, garnet-sillimanite gneisses, metaquartzites, calc-silicate rocks), orthogneisses of largely granitoid composition, and charnockitic rocks metamorphosed under upper amphibolite to granulite facies conditions (Cooray, 1994). Folding, faulting and foliation are the other common structural features in the Highland Complex (Cooray, 1984). Folds of all scales can be observed in the Highland Complex and most of them are regular and have roughly the same trend. It can be observed from the Figure 1.4, majority of the folds pitch either towards the north or south. Further, folds pitching in both directions which indicate fold interference and also sub-horizontal recumbent folds which indicate intense deformation are common in many areas. These folds form a regular pattern of synclines and anticlines called the Taprobanian fold system (Figure 1.4).

The Vijayan Complex (former eastern Vijayan Complex), which is situated in the east and south of the Highland Complex, covers the whole eastern and southeastern parts of the island (Figure 1.3). The Vijayan rocks consist mainly of granitoids, migmatitic and granitic gneisses, augen gneisses, minor amphibolites and scattered metasediments (metaquartzites, calc-silicate rocks), metamorphosed under amphibolite facies conditions (Cooray, 1984; 1994). Common geological structures of the Vijayan Complex are foliation, folding, jointing and mineral elongation. Foliation is the most common structure of the Complex and foliation planes are