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**GEOLOGICAL SURVEY OF CANADA
OPEN FILE 8594**

**One-dimensional Layered Earth Models of Canada
for GIC Applications**

Part 1. General Description

L. Trichtchenko, P.A. Fernberg, and D.H. Boteler

2019

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Part 1. General Description

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2019

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Table of Contents

Summary.....	5
Introduction.....	6
1. Geomagnetic data.....	6
2. Modelling of the geoelectric field for GIC applications.....	7
3. Background on Earth resistivity and its measurements.....	11
4. One-dimensional Earth resistivity models for 10 Canadian provinces.....	15
4.1. Alberta	16
4.2. British Columbia	21
4.3. Manitoba	27
4.4. New Brunswick.....	33
4.5. Newfoundland and Labrador.....	37
4.6. Nova Scotia	41
4.7. Ontario	45
4.8. Prince Edward Island	50
4.9. Quebec	53
4.10. Saskatchewan	58
5. Conclusions	64
6. References.....	65

Supplementary information on detailed descriptions of the layered earth resistivity models for each province is presented in OF 8595, <https://doi.org/10.4095/314805>

Summary

Evaluation of the impacts of space weather on ground infrastructure requires information on the size of geomagnetically induced (telluric) currents. For estimation of these currents in places where they are/were not recorded, numerical modelling needs to be employed. The most common approach in the modelling of geomagnetically induced currents is based on the knowledge of the geoelectric field driving these currents. Because there are no continuous measurements of the geoelectric fields in many areas where the power networks are located, the common method is based on utilisation of the available geomagnetic observations recorded in the area together with the surface impedance of the Earth, derived from the short-duration magnetotelluric surveys.

The compilation of two reports (current, main Part 1 and supplementary Part 2) present one-dimensional resistivity models and corresponding surface impedance variations for 10 Canadian provinces (located below 60 degrees in latitude), as derived from the available publications. The supplementary report provides a set of 10 Appendices with the detailed description of the geological settings of each province, justification for choice of the one-dimensional areas (zones) for each province and values of resistivities and depths.

The presented main part summarises the one-dimensional Earth resistivity models and obtained surface impedance for each province including maps with identification of different Zones, as well as Tables and plots, showing the resistivity variations with depths and plots presenting the variations of surface impedance amplitude and phase with frequency. Thus, information presented in the main part can be immediately used for modelling of the geoelectric fields in each province.

Detailed descriptions with justification for values of layered Earths resistivity models for each province, as well as details on the locations of the identified zones, together with the list of references are presented in: Trichtchenko, L., Fernberg, P.A., Boteler, D.H., 2019. One-dimensional Layered Earth Models of Canada for GIC Applications. Part 2. Detailed Description; Geological Survey of Canada, Open File 8595, 587 pp. <https://doi.org/10.4095/314805>. In the following text this reference is cited as OF 8595. This detailed description can be used for better justification of the presented geoelectrical parameters and location of defined zones and give the opportunity to update the specific parameters when the new information becomes available.

Introduction

In order to properly address the impacts of telluric currents (also named as “geomagnetically induced currents”, further abbreviated as GIC) on ground infrastructure, amplitude and direction of the geoelectric field at a given place and at a given moment of time are required. Usually, these geoelectric fields are modelled based on the available geomagnetic measurements and surface impedance models. The report is structured as follows: Part 1 presents the location and data availability of the geomagnetic observations in Canada, Part 2 described the simplest and most common theoretical background for calculation of the geoelectric field, Part 3 presents the general information on Earth resistivity and its measurements. The layered earth resistivity models for each province are presented in the Part 4, summarised as Maps (locations of the identified 1-D Zones), Tables (with resistivities and depths and thicknesses), accompanied graphs with resistivities vs. depth and calculated variations of surface impedances (amplitude and phase).

1. Geomagnetic data

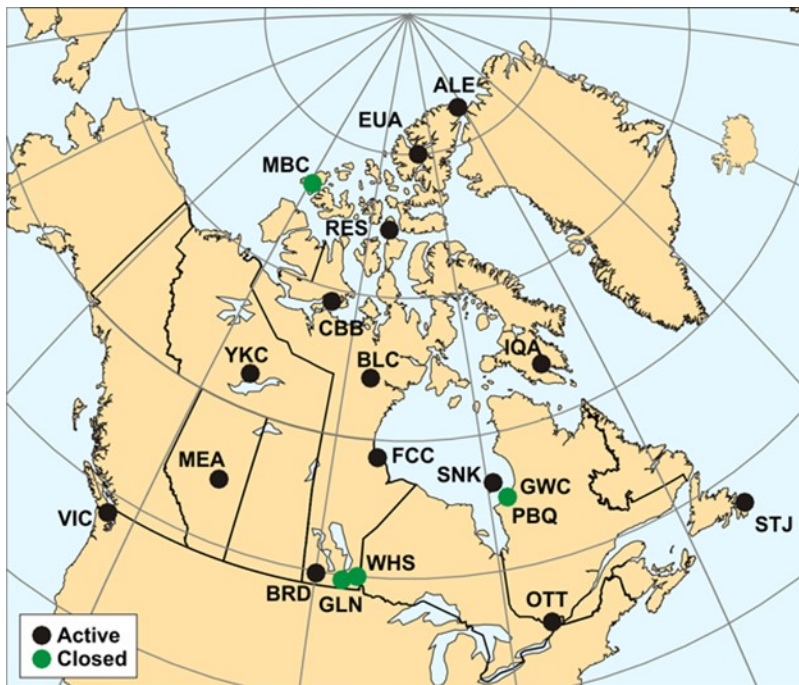


Figure 1.1 Map of Canadian magnetic observatories. The conversion of observatory naming from IAGA 3-letter code to the full name can be found in Table 1.1

The 1-minute sampled geomagnetic data from Canadian Observatories (Figure 1.1) are available from <http://www.geomag.nrcan.gc.ca/index-en.php> or <http://www.geomag.nrcan.gc.ca/index-fr.php>. The measurements of three components of magnetic field are done by use of the fluxgate magnetometer (for instrument description see <http://www.geomag.nrcan.gc.ca/obs/canmos-en.php>), which samples the magnetic field at 8 Hz, which then resampled in several steps to 1 sec., 5 sec., and 1 min data sampling rates. The detailed description of the filters and the whole

procedure can be found in the INTERMAGNET Technical Reference Manual at <http://intermagnet.org/publication-software/technicalsoft-eng.php>. These 1 minute digital data are available for all Canadian Observatories (see the map on Figure 1.1) for almost 40 years. The exact years of data availability for each observatory are listed below in Table 1.1.

Table 1.1 Location, 3-letter code and years of availability of digital data for Canadian magnetic Observatories.

Name	Code	Latitude (°)	Longitude (°)	Opened (UT)	Closed (UT)
Baker Lake	BLC	64.318	263.988	1974-01-01	
Brandon	BRD	49.870	260.026	2007-06-08	
Cambridge Bay	CBB	69.123	254.969	1972-07-20	
Eureka	EUA	80.000	274.100	2005-05-03	
Fort Churchill	FCC	58.759	265.912	1973-01-01	
Glenlea	GLN	49.645	262.880	1980-09-30	2006-05-01
Great Whale River	GWC	55.3	282.25	1973-01-01	1984-08-18
Iqaluit	IQA	63.753	291.482	1996-01-01	
Mould Bay	MBC	76.315	240.638	1980-01-01	1997-07-01
Meanook	MEA	54.616	246.653	1972-08-01	
Ottawa	OTT	45.403	284.448	1973-01-01	
Poste de-la-Baleine	PBQ	55.277	282.255	1984-09-09	2007-11-01
Resolute Bay	RES	74.690	265.105	1974-01-01	
Sanikiluaq	SNK	56.500	280.800	2006-11-06	
St Johns	STJ	47.595	307.323	1972-07-31	
Victoria	VIC	48.520	236.580	1973-01-01	
Whiteshell	WHS	49.8	264.75	1977-01-01	1979-12-31
Yellowknife	YKC	62.480	245.518	1975-01-01	

2. Modelling of the geoelectric field for GIC applications

This Part describes the method used to obtain geoelectric field from the known geomagnetic recordings at the Earth's surface.

For description of the geo-electromagnetic field, the coordinate system with axis x north, y east, and z vertically downwards is used. For the natural geomagnetic variations produced by space weather events (periods from 1sec to 24 hours) and Earth resistivity above 1 Ohm·m, the displacement currents are small in comparison with conductivity currents. Therefore, electric and magnetic fields in the frequency domain can be given by the diffusion equations in frequency domain (see, for example, [1])

$$\frac{d^2 E}{dz^2} = i\omega\mu\sigma E \quad (1)$$

$$\frac{d^2 H}{dz^2} = i\omega\mu\sigma H \quad (2)$$

Solutions for each layer have the form

$$E = A(e^{-kz} + Re^{kz}) \quad (3)$$

and

$$H = A\left(\frac{e^{-kz}}{Z_0} - R\frac{e^{kz}}{Z_0}\right) \quad (4)$$

where A and R are the amplitude and reflection coefficient, $k = \sqrt{i\omega\mu\sigma}$ is the propagation constant, and

$Z_0 = \frac{i\omega\mu}{k} = \sqrt{\frac{i\omega\mu}{\sigma}}$ is the characteristic impedance (ratio of the electric and magnetic fields for the uniform media).

For our case, when the magnetic field at the surface of the Earth (1st layer) is known from the magnetic observations, the electric field can be obtained from the ratio (impedance) of magnetic and electric fields

$$E_{surface} = Z_1 H_{surface} \quad (5)$$

The impedance at the surface of any layer n can be found by applying the recursion relation for the impedance of an N - layered half-space ([1], p.293).

$$Z_n = i\omega\mu \left(\frac{1 - r_n e^{-2k_n d_n}}{k_n (1 + r_n e^{-2k_n d_n})} \right) \quad (6)$$

where d_n, k_n are the thickness and propagation constant of the layer n ,

$$r_n = \frac{1 - k_n \frac{Z_{n+1}}{i\omega\mu}}{1 + k_n \frac{Z_{n+1}}{i\omega\mu}} \quad (7)$$

and for the last layer

$$Z_N = \frac{i\omega\mu}{k_N} \quad (8)$$

Thus, in order to find the variations of the geoelectric field, equations (5)-(8) need to be solved.

1. The recordings of the magnetic field are of magnetic induction (denoted as $B(t)$, nT, related to magnetic field strength as $B = H/\mu$, where μ is the magnetic permeability of media), for the period of the interest are obtained from the geomagnetic observatory (see example in Figure 2.2a). A discrete Fourier transform of the series of N data points of magnetic field horizontal components, $B_{x,y}(t_k)$ gives the spectrum of the magnetic field horizontal components variations

$$B_{x,y}(\omega_n) = \sum_{k=0}^{N-1} B_{x,y}(t_k) \exp(i\omega_n t_k) \quad (9)$$

The variations of the amplitude spectrum for the north component of magnetic field B_x in frequency domain is shown in Fig 3b.

2. Obtain the surface impedance values $Z(\omega)$ from the Earth conductivity model of given observatory. Because the surface impedance is the ratio of the geoelectric to geomagnetic field, the values of the geoelectric field in the frequency domain can easily be calculated as the next step.

3. Multiply the geomagnetic field in frequency domain by the surface impedance gives the spectra of the electric field at the ground, as shown for the E_y component in Fig. 2.2d.

$$E_x(\omega_n) = Z(\omega_n) B_y(\omega_n) / \mu \quad (10)$$

$$E_y(\omega_n) = -Z(\omega_n) B_x(\omega_n) / \mu \quad (11)$$

where μ is magnetic permeability of the media, in this case equal to the magnetic permeability of the free space, μ_0 .

4. An inverse discrete Fourier transform can then be used to find the electric field variations in the time domain (Fig. 2.2c).

$$E_{x,y}(t_k) = \frac{1}{N} \sum_{n=0}^{N-1} E_{x,y}(\omega_n) \exp(-i\omega_n t_k) \quad (12)$$

The following steps (Figure 2.1) summarise the procedure used to calculate geoelectric field based on the geomagnetic data and surface impedance:

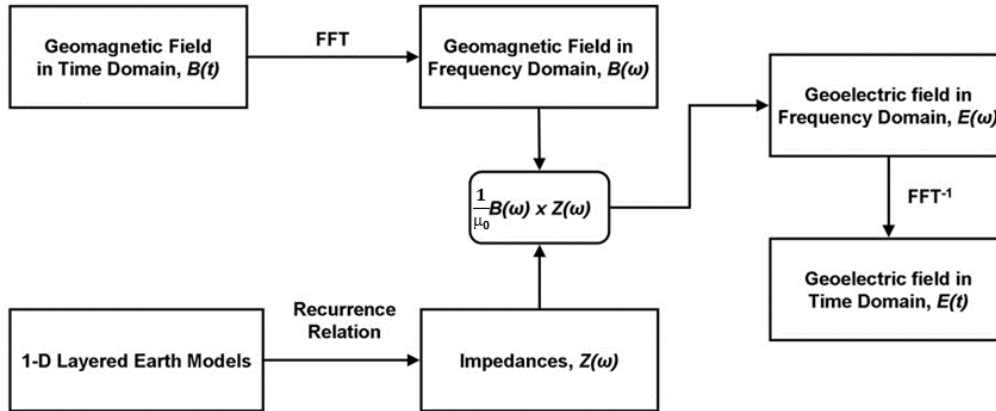


Figure 2.1. Schematics for calculation of electric field

The illustrative examples of variations of the geomagnetic and geoelectric fields in time domain and frequency domain, x and y components, are shown in Figure 2.2, a-d.

In order to find the electric field at the location of the observatory, the values of the surface impedance are needed, which can be derived from the Earth resistivity (or its inverse, Earth conductivity) models for each observatory.

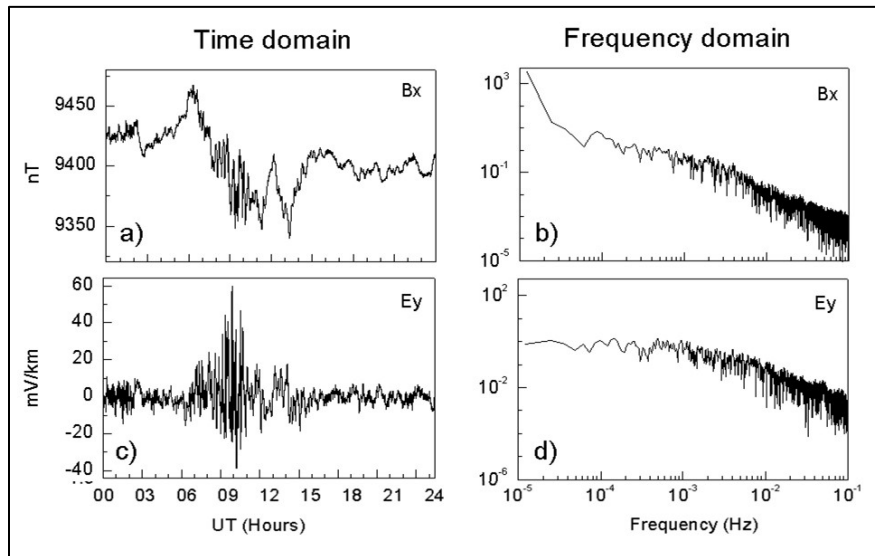


Figure 2.2. The variations of north-south component of magnetic field **(a)** in time domain (observatory recordings) and **(b)** in frequency domain (obtain by using FFT), and variations of east-west component of geoelectric field **(c)** in time domain and **(d)** in frequency domain, obtained as described above.

3. Background on Earth resistivity and its measurements

The size of the telluric electric fields produced by geomagnetic disturbances depends on the Earth resistivity down to the depth of penetration of the geomagnetic disturbances. We are concerned with geomagnetic field variations with periods from minutes to hours with penetration depths ranging from a few kilometres to hundreds of kilometres. Thus, we need information about the resistivity not just of the surface rock or soil layers, but deeper into the Earth.

On the large scale, Earth's interior structure is divisible into four main layers: crust, mantle, outer core, and inner core (Figure 3.1). Each layer can be further subdivided based on unique physical differences. The outermost, thin, rigid crust is underlain by the dense, hot layer of semi-solid rock of the mantle. Changes with depth of temperature and pressure, changes to abundance and distribution of conductive minerals, and pore volume and fluid composition all change the resistivity, going from higher resistivity in the crust to low resistivity in the mantle.

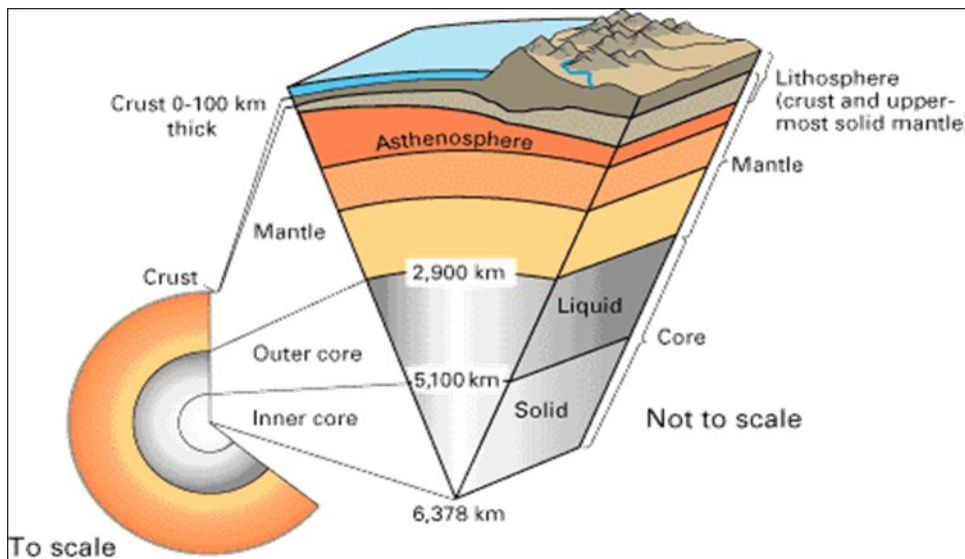


Figure 3.1. Schematics of the internal structure of the Earth (<http://pubs.usgs.gov/gip/dynamic/inside.html>)

The resistivity of Earth materials varies widely, as shown in Figure 3.2, with a considerable overlap of range between different materials. Common rocks show a resistivity range from 10 to 100,000 Ohm·meters ($\Omega\cdot\text{m}$), with values for various rock types provided in Tables 3.1 and 3.2. Geologic age of the rock, particularly for sedimentary rocks, also has an effect on resistivity values as shown in Table 3.2, whereby compaction associated with increasing thickness of overlying rock reduces pore space and amount of inter-pore water thereby increasing the rock resistivity. Resistivity will vary among different types of sedimentary rock, being high where there is proportionally more limestone than shale and sandstone, and least for shale dominant rock especially if carbonaceous-rich.

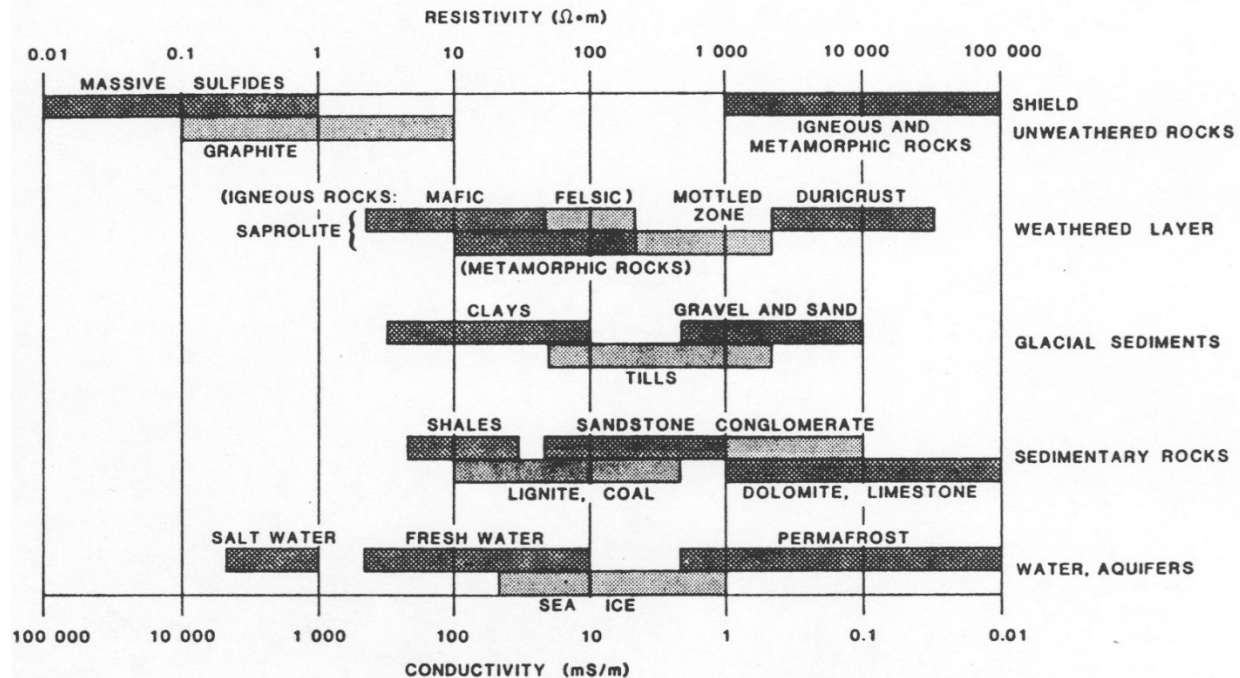


Figure 3.2. Range of resistivities for common Earth materials (from [2]).

Worldwide, the mid-to-lower crust exhibits lower resistivity compared to the upper crust (typically crystalline rock several km thick) due to temperature and pressure increasing with depth. However the entire crust has a higher resistivity than the underlying mantle. In the mantle the increasing pressure and temperature with depth cause the olivine and pyroxene minerals to undergo a phase change to a more dense form that greatly decreases the electrical resistivity.

Table 3.1. Resistivity values for some common rocks (modified from [3])

Consolidated Sedimentary Rock	Range ($\Omega\cdot m$)	Volcanic (extrusive) Rock	In situ ($\Omega\cdot m$)
Argillite	74-840	Basalt	800
Conglomerate	2,000-13,000	Diabase	450
Dolomite	700-2,500	Diabase	450
Greywacke	400-1,200		
		Plutonic (intrusive) Rock	In situ ($\Omega\cdot m$)
Limestone	350-6,000	Gabbro	490
Sandstone	1,000-4,000	Diorite	7,000
Shale	20-2,000	Syenite	2,400
Slate	340-1,600	Granite	4,300

Table 3.2. Resistivity values for water-bearing rocks of various types [4]

Geologic age	Marine sand, shale, greywacke	Terrestrial sands, claystone, arkose	Volcanic Rocks (basalt, rhyolite, tuffs)	Intrusive Rocks (granite, gabbro)	Sedimentary Rock (limestone, dolomite, salt)
Quaternary, Tertiary	1 - 10	15 - 20	10 - 200	500 - 2000	50 - 5000
Mesozoic	5 - 20	25 - 100	20 - 500	500 - 2000	100 - 10000
Carboniferous	10 - 40	50 - 300	50 - 1000	1000 - 5000	200 - 100000
Pre-Carboniferous Paleozoic	40 - 200	100 - 500	100 - 2000	1000 - 5000	10000 - 100000
Precambrian	100 - 2000	300 - 5000	200 - 5000	5000 - 20000	10000 - 100000

Both the crust and mantle can exhibit lateral variations of electrical resistivity on scales of tens to hundred kilometres due to effects from deep-seated geological structure, tectonic mechanisms, and changes in pressure, temperature and mineralogy, such that regional resistivities are either higher or lower than globally averaged values [5].

Mechanisms that can alter the resistivity of crustal rocks and mantle include: changes to amount of minor constituents (such as graphite and sulphides) and their degree of interconnection; presence of partial melt fluids and aqueous fluids; and enhanced electronic conduction at grain-boundary films of carbon [6,7]. Subduction can drag down to crustal depths water saturated and carbonaceous and/or sulphide rich sediments which are more conductive than surrounding deep crust or mantle [8]. Overburden layer also exhibits a wide resistivity range, from below 10 $\Omega\cdot\text{m}$ to 10,000 $\Omega\cdot\text{m}$, which depends on porosity and groundwater and clay contents [9].

The magnetotelluric (MT) method is the geophysical technique with the ability to provide an image of the Earth's conductivity structure over a depth range from near surface to the deep mantle. The ratio of the electrical and magnetic field strengths, as a function of frequency, provides a measurement of electrical impedance which in turn is used to calculate the resistivity at various depths. The depth to which resistivity structures can be imaged depends on the depth of penetration of the electromagnetic fields. This is dependent on the presence of local near-surface structures of low-resistivity and the frequency and intensity of the natural electromagnetic variations [10]. The MT technique measures a "bulk" apparent resistivity of the Earth material over a large area at a range of depths.

In-situ measurement of resistivity are also possible, as done in oil and gas exploration wells by the use of probes lowered into a well, often to depths of thousands of meters. As well, an induction

tool can measure resistivity up to 5m or more from the borehole and provides a good representation of resistivity through the surface of surrounding rock. Comparison of petroleum-well induction logs has shown a very good match with resistivity derived from MT soundings [11, 12]. Laboratory measurements of the resistivity exhibited by samples of different rock types also provides information whereby the resistivity of an area can be inferred if the geology of the area is known.

4. One-dimensional Earth resistivity models for 10 Canadian provinces

For each province, a number of layered Earth models were identified, where changes in resistivity can be approximated in only one direction: vertically, as presented in Figure 4.1. Lateral changes are taken into account by the changes in the resistivity models from location to location. Determination of the conductivity into the deep Earth is necessary because the low frequency magnetic field variations penetrate several hundred kilometres through the entire crust and into the mantle. Hence, the resulting surface geoelectric field is influenced by the combined response through several hundred km into the Earth's interior.

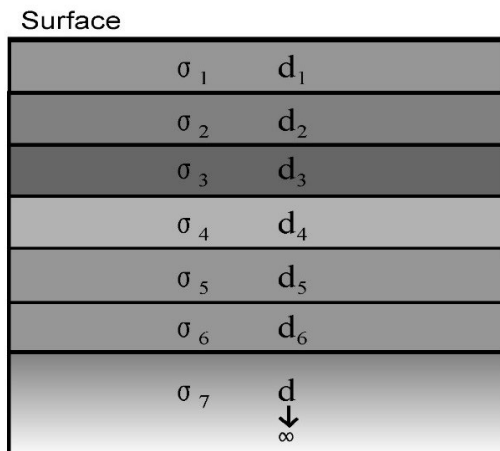


Figure 4.1. General scheme of the Earth conductivity structure for 1-d layered conductivity model. Here σ is the conductivity and d is the depth of each layer, with the bottom layer of the half-space.

From the surface downward the layers of a 1D model are as follows: overburden; sedimentary rocks accumulated in a depositional basin (not always present); basement complex (sedimentary, volcanic and intrusive igneous, and metamorphosed rocks) that is considered to be the upper crust; middle and lower crust (sometimes combined into a single layer); and mantle.

The layered Earth resistivity models for each province are presented in the following 10 paragraphs summarised as Maps (locations of the identified 1-D Zones), Tables (with resistivities and depths and thicknesses), accompanied graphs with resistivities vs. depth and calculated variations of surface impedances (amplitude and phase) with frequency, based on formulas (6) to (8).

4.1 Alberta

Map showing the areas of different Earth's resistivity models for Alberta is presented in Figure 4.1.1, Table 4.1.1 and Figure 4.1.2 summarize the resistivity models, and Figure 4.1.3 shows variations of surface impedance with frequency.

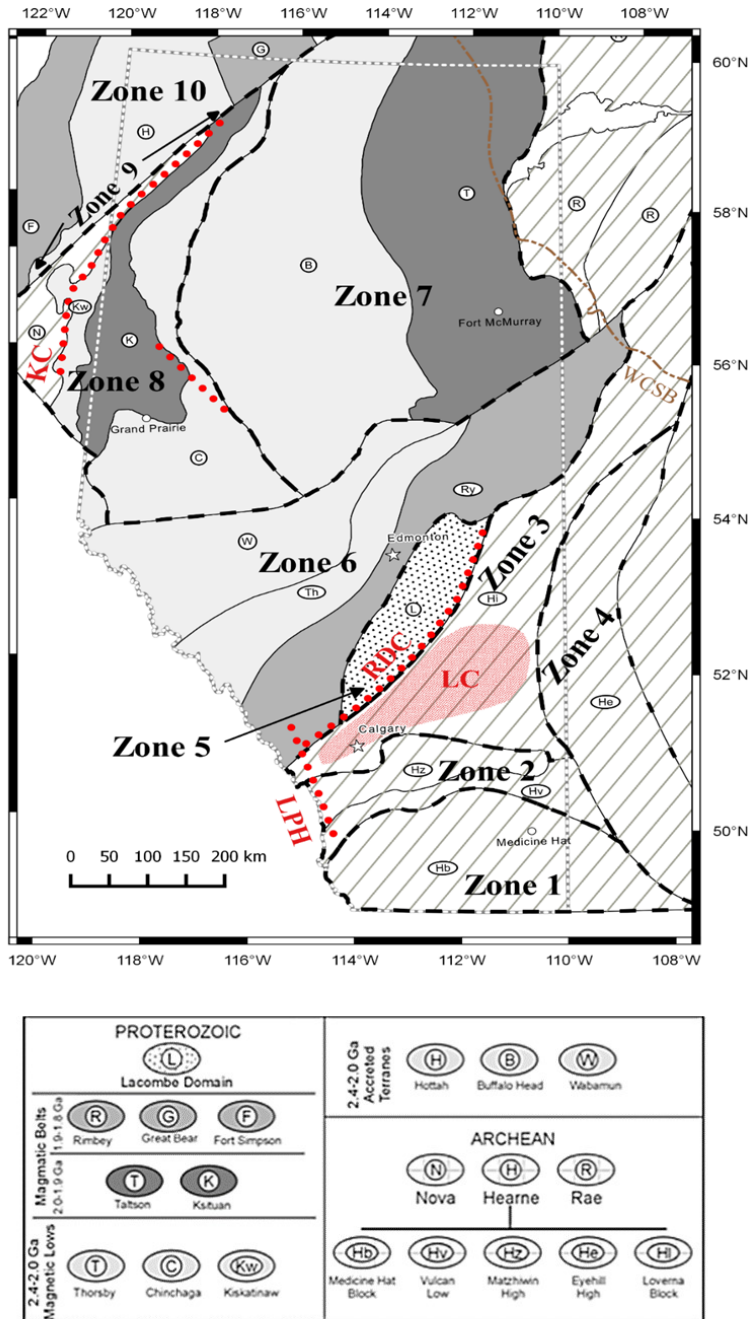


Figure 4.1.1. Division of Alberta into 10 layered Earth zones (Zone 9 is located at boundary between Zones 8 and 10) on top of the map of tectonic elements and conductive anomalies (general location), of Precambrian age, underlying Alberta after [11]. See OF 8595, Appendix 1 for more details.

Table 4.1.1. Summary of 1D Earth Resistivity Models for Alberta (Zones 1-6)

Layer	Zone 1 (Medicine Hat Block)	Zone 2 (Vulcan Structure)	Zone 3 (Loverna Block)	Zone 4 (Eyehill Domain)	Zone 5 (Lacombe Domain)	Zone 6 (Rimbey, Thorsby & Wabamun Domains)
1 – Over burden	75 m thick 30 ohm.m	50 m thick 30 ohm.m	40 m thick 30 ohm.m	50 m thick 50 ohm.m	35 m thick 30 ohm.m	65 m thick 50 ohm.m
2 – Sediment.B asin	0-2.2 km 2.2 km thick 30 ohm.m	0-2.4 km 2.4 km thick 25 ohm.m	0-2.9 km 2.9 km thick 6 ohm.m	0-2 km 2 km thick 10 ohm.m	0-3.1 km 3.1 km thick 20 ohm.m	0-2.7 km 2.7 km thick 15 ohm.m
3 – Upper Crust	2.2-15 km 13 km thick 385 ohm.m	2.4-24 km 21.6 km thick 3000 ohm.m	2.9-19 km 16 km thick 2000 ohm.m	2-19 km 17 km thick 1900 ohm.m	3.1-19 km ~ 16 km thick 440 ohm.m	2.7-12 km ~ 9 km thick 3000 ohm.m
4 – Middle Crust	15-27.5 km 12.5 km thick 2500 ohm.m	24-37 km 13 km thick 2000 ohm.m	19-29 km 10 km thick 3000 ohm.m	19-29 km 10 km thick 1700 ohm.m	19-29 km 10 km thick 900 ohm.m	12-29 km 17 km thick 2300 ohm.m
5 – Lower Crust	27.5-45 km 17.5 km thick 2500 ohm.m	37-45 km 8 km thick 4000 ohm.m	29-41 km 12 km thick 620 ohm.m	29-43 km 14 km thick 850 ohm.m	29-39 km 10 km thick 330 ohm.m	29-39 km 10 km thick 2100 ohm.m
6 – Upper Mantle	45-100 km 55 km thick 2250 ohm.m	45-100 km 55 km thick 2000 ohm.m	41-100 km 59 km thick 150 ohm.m	43-100 km 57 km thick 500 ohm.m	39-100 km 61 km thick 950 ohm.m	39-100 km 61 km thick 1400 ohm.m

Table 4.1.1. (continued) Summary of 1D Earth Resistivity Models for Alberta (Zones 1-6)

Layer	Zone 1 (Medicine Hat Block)	Zone 2 (Vulcan Structure)	Zone 3 (Loverna Block)	Zone 4 (Eyehill Domain)	Zone 5 (Lacombe Domain)	Zone 6 (Rimbey, Thorsby & Wabamun Domains)
7 – Upper Mantle	100-250 km 150 km thick 550 ohm.m	100-250 km 150 km thick 260 ohm.m	100-250 km 150 km thick 230 ohm.m	100-250 km 150 km thick 530 ohm.m	100-250 km 150 km thick 160 ohm.m	100-250 km 150 km thick 160 ohm.m
8 – Upper Mantle	250-410 km 160 km thick 40 ohm.m	250-410 km 160 km thick 70 ohm.m	250-410 km 160 km thick 90 ohm.m	250-410 km 160 km thick 90 ohm.m	250-410 km 160 km thick 40 ohm.m	250-410 km 160 km thick 50 ohm.m
9 – Transit Zone	410-520 km 110 km thick 8 ohm.m	410-520 km 110 km thick 8 ohm.m	410-520 km 110 km thick 8 ohm.m	410-520 km 110 km thick 8 ohm.m	410-520 km 110 km 20 ohm.m	410-520 km 110 km 20 ohm.m
10 – Transit Zone	520-670 150 km thick 2.4 ohm.m	520-670 150 km thick 2.4 ohm.m	520-670 150 km thick 2.4 ohm.m	520-670 150 km thick 2.4 ohm.m	520-670 150 km 5.6 ohm.m	520-670 150 km 5.6 ohm.m
11 – Lower Mantle	670-900 km 230 km thick 0.89 ohm.m	670-900 km 230 km thick 0.89 ohm.m	670-900 km 230 km thick 0.89 ohm.m	670-900 km 230 km thick 0.89 ohm.m	670-900 km 230 km thick 1.58 ohm.m	670-900 km 230 km thick 1.58 ohm.m
12 – Lower Mantle	900-1000 km 100 km thick 0.47 ohm.m	900-1000 km 100 km thick 0.47 ohm.m	900-1000 km 100 km thick 0.47 ohm.m	900-1000 km 100 km thick 0.47 ohm.m	900-1000 100 km 0.89 ohm.m	900-1000 100 km 1.12 ohm.m

Table 4.1.1. (continued) Summary of 1D Resistivity Models for Alberta (Zones 7-10)

Layer	Zone 7 (Buffalo Head, Taltson)	Zone 8 (Chinchaga, Ksituan, Kiskatinaw, Nova)	Zone 9 (Great Slave Lake shear zone)	Zone 10 (Great Bear, Hottah, Fort Simpson)
1 – Overburden	50 m thick 30 ohm.m	25 m thick 30 ohm.m	25 m thick 15 ohm.m	175 m thick 30 ohm.m
2 – Sedimentary Basin	0-1.4 km 1.4 km thick 10 ohm.m	0-3.3 km 3.3 km thick 10 ohm.m	0-1.9 km 1.9 km thick 10 ohm.m	0-1.9 km 1.9 km thick 10 ohm.m
3 – Upper Crust	1.4-13 km 11.6 km thick 3000 ohm.m	3.3-15 km 11.7 km thick 900 ohm.m	1.9-12 km 10.1 km thick 4200 ohm.m	1.9-8 km 6 km thick 1000 ohm.m
4 – Middle Crust	13-29 km 16 km thick 1750 ohm.m	15-30 km 15 km thick 275 ohm.m	12-24 km 12 km thick 4500 ohm.m	8-18 km 10 km thick 1300 ohm.m
5 – Lower Crust	29-38 km 9 km thick 1200 ohm.m	30-39 km 9 km thick 360 ohm.m	24-40 km 16 km thick 4500 ohm.m	18-40 km 22 km thick 800 ohm.m
6 – Upper Mantle	38-100 km 62 km thick 1400 ohm.m	39-100 km 61 km thick 315 ohm.m	40-100 km 60 km thick 1600 ohm.m	40-100 km 60 km thick 500 ohm.m
7 – Upper Mantle	100-250 km 150 km thick 635 ohm.m	100-250 km 150 km thick 660 ohm.m	100-250 km 150 km thick 680 ohm.m	100-250 km 150 km thick 625 ohm.m
8 – Upper Mantle	250-410 km 160 km thick 50 ohm.m	250-410 km 160 km thick 50 ohm.m	250-410 km 160 km thick 50 ohm.m	250-410 km 160 km thick 50 ohm.m
9 – Transition Zone	410-520 km 110 km thick 20 ohm.m	410-520 km 110 km thick 20 ohm.m	410-520 km 110 km thick 20 ohm.m	410-520 km 110 km thick 20 ohm.m
10 – Transition Zone	520-670 150 km thick 5.62 ohm.m	520-670 150 km thick 5.62 ohm.m	520-670 150 km thick 5.62 ohm.m	520-670 150 km thick 5.62 ohm.m
11 – Lower Mantle	670-900 km 230 km thick 1.58(i) ohm.m	670-900 km 230 km thick 1.58(i) ohm.m	670-900 km 230 km thick 1.58(i) ohm.m	670-900 km 230 km thick 1.58(i) ohm.m
12 – Lower Mantle	900-1000 km 100 km thick 1.12 ohm.m	900-1000 km 100 km thick 1.12 ohm.m	900-1000 km 100 km thick 1.12 ohm.m	900-1000 km 100 km thick 1.12 ohm.m

Summary of the changes of resistivity with depth for all Zones in Alberta

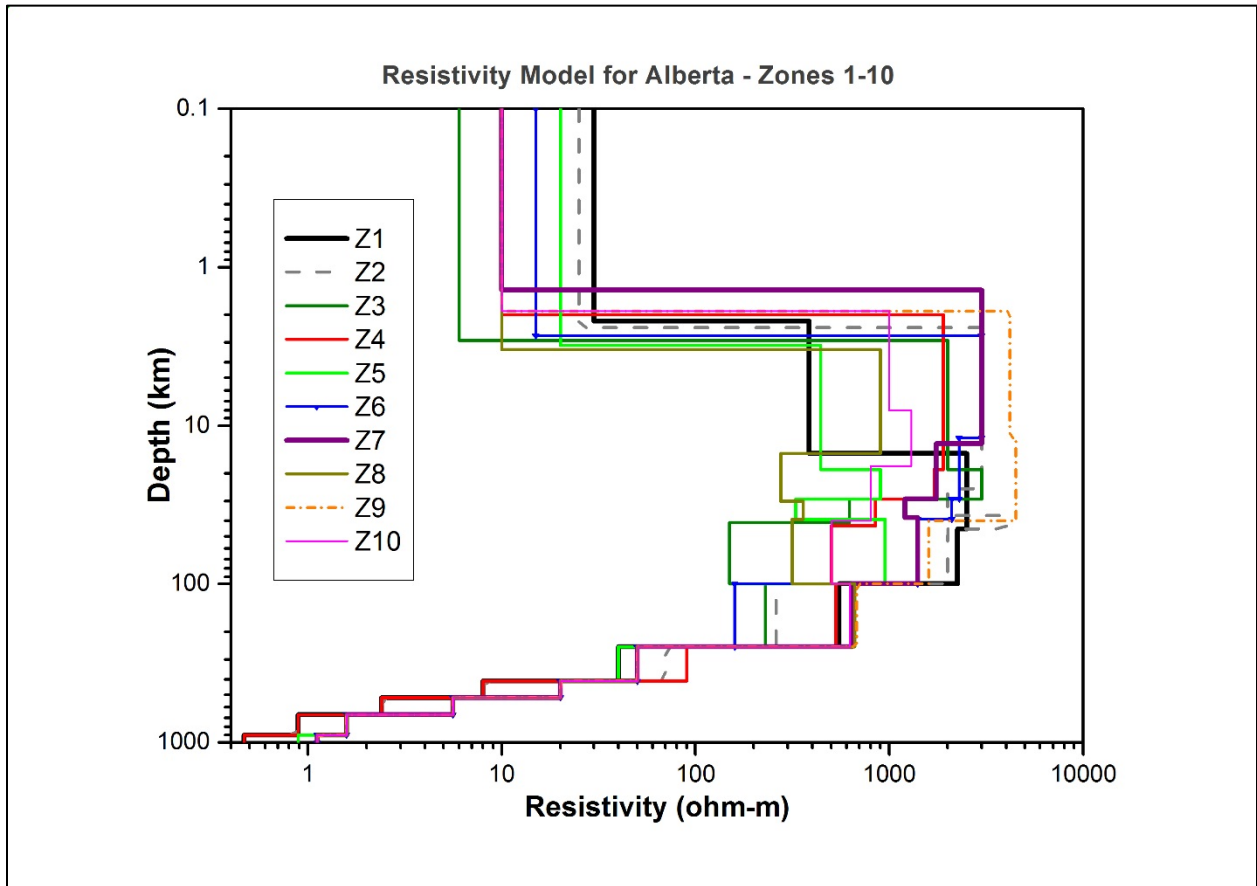


Figure 4.1.2. Variation of the resistivity for 10 different Zones (Z1 to Z10, colour coded) of Alberta. Vertical scale is depth in kilometers, horizontal scale is resistivity in Ohm·meter.

Variations of surface impedance with frequency for all 10 resistivity models

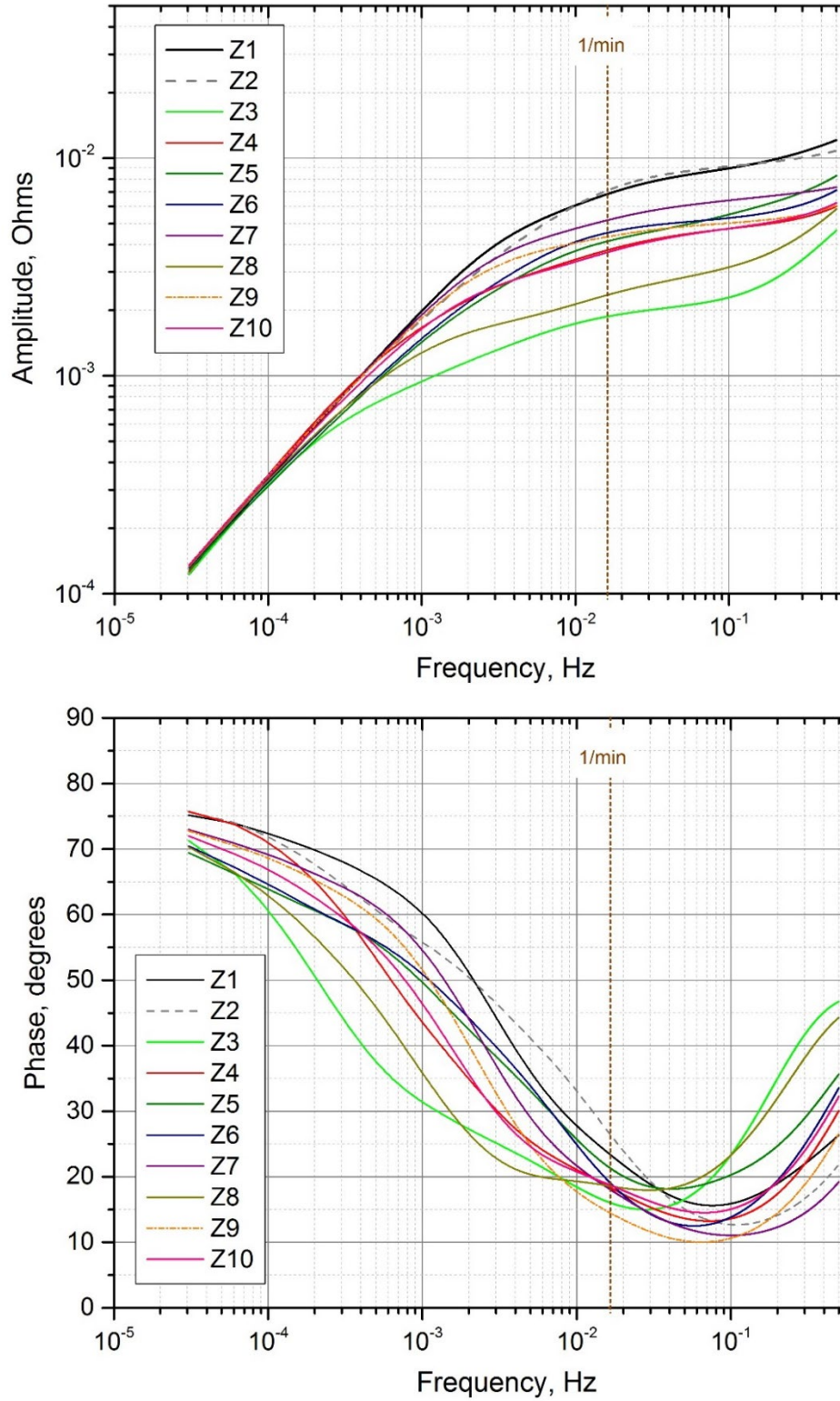


Figure 4.1.3. Variations of surface impedances (top-amplitude, bottom-phase) with frequency for 10 layered Earth models

4. 2. British Columbia

Map showing the areas of different Earth's resistivity models for British Columbia is presented in Figure 4.2.1, Table 4.2.1 and Figure 4.2.2 summarize the resistivity models, and Figure 4.2.3 shows variations of surface impedance with frequency.

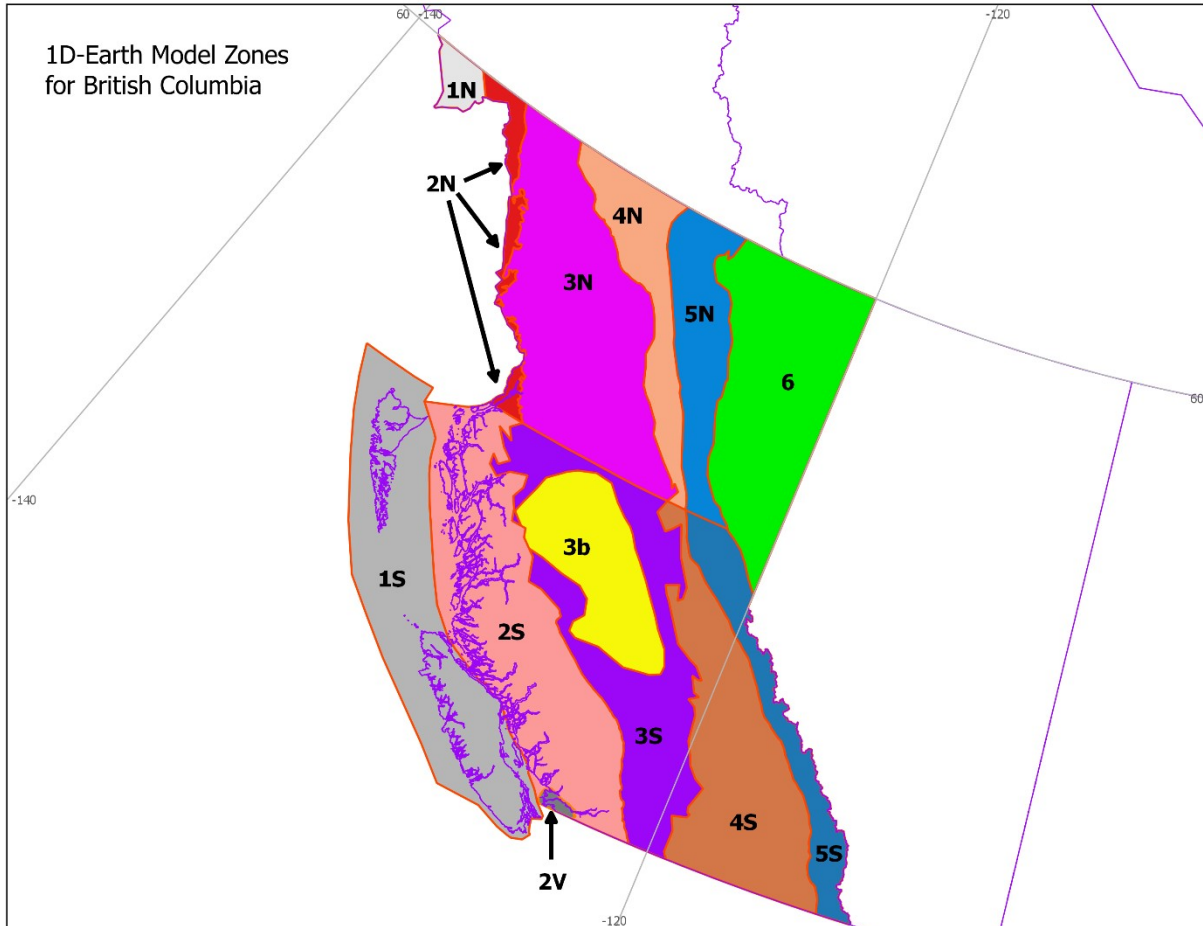


Figure 4.2.1. Division of British Columbia into 13 layered Earth zones (with two major parts, North, N and South, S). See OF 8595, Appendix 2 for more explanations.

Table 4.2.1. Summary of 1D Earth Resistivity Models for British Columbia (Zones 1-2N)

Layer	Zone 1 (Insular Belt)	Zone 2S (Coast Belt, south)	Zone 2V (Coast Belt/ Vancouver)	Zone 2N (Coast Belt, north)
1 – Overburden	25 m thick 30 ohm.m	2 m thick 115 ohm.m	0.25 km thick 100 ohm.m	2 m thick 115 ohm.m
2 – Sedimentary Basin	0-1 km 1 km thick 25 ohm.m	absent	0.25-2.75 km 2.5 km thick 25 ohm.m	absent
3 – Upper Crust	1-9.5 km 8.5 km thick 610 ohm.m	0-11 km 11 km thick 820 ohm.m	2.75-11 km 8.25 km thick 75 ohm.m	0-12.5 km 12.5 km thick 43000 ohm.m
4 – Middle Crust	9.5-20 km 10.5 km thick 310 ohm.m	11-23 km 12 km thick 810 ohm.m	11-20 km 9 km thick 150 ohm.m	12.5-28 km 15.5 km thick 34800 ohm.m
5 – Lower Crust	20-30 km 10 km thick 90 ohm.m	23-34.5 km 11.5 km thick 260 ohm.m	20-35 km 15 km thick 110 ohm.m	28-31.5 km 3.5 km thick 26000 ohm.m
6 – Upper Mantle	30-100 km 70 km thick 200 ohm.m	34.5-100 km 65.5 km thick 120 ohm.m	35-100 km 65 km thick 115 ohm.m	31.5-100 km 68.5 km thick 25800 ohm.m
7 – Upper Mantle	100-150 km 50 km thick 230 ohm.m	100-150 km 50 km thick 120 ohm.m	100-150 km 50 km thick 150 ohm.m	100-250 km 150 km thick 2300 ohm.m
	150-250 km 100 km thick 200 ohm.m	150-250 km 100 km thick 210 ohm.m	150-250 km 100 km thick 210 ohm.m	
8 – Upper Mantle	250-410 km 160 km thick 40 ohm.m	250-410 km 160 km thick 50 ohm.m	250-410 km 160 km thick 50 ohm.m	250-410 km 160 km thick 100 ohm.m
9 – Transition Zone	410-520 km 110 km thick 11 ohm.m	410-520 km 110 km thick 20 ohm.m	410-520 km 110 km thick 20 ohm.m	410-520 km 110 km thick 20 ohm.m
10 – Transition Zone	520-670 150 km thick 2 ohm.m	520-670 150 km thick 5.62 ohm.m	520-670 150 km thick 5.62 ohm.m	520-670 150 km thick 5.62 ohm.m
11 – Lower Mantle	670-900 km 230 km thick 1.22 ohm.m	670-900 km 230 km thick 1.58 ohm.m	670-900 km 230 km thick 1.58 ohm.m	670-900 km 230 km thick 1.58 ohm.m
12 – Lower Mantle	900-1000 km 100 km thick 0.77 ohm.m	900-1000 km 100 km thick 0.89 ohm.m	900-1000 km 100 km thick 0.89 ohm.m	900-1000 km 100 km thick 0.89 ohm.m

Table 4.2.1 (continued, Zones 3S-4N)

Layer	Zone 3S (Intermontane Belt, south)	Zone 3B (Intermontane Belt Nechako Basin)	Zone 3N (Intermontane Belt, north)	Zone 4S (Omineca Belt, south)	Zone 4N (Omineca Belt, north)
1 – Overburden	10 m thick 70 ohm.m	50 m thick 75 ohm.m	10 m thick 70 ohm.m	2 m thick 70 ohm.m	15 m thick 70 ohm.m
2 – Sedimentary	absent	0-2.5 km 2.5 km thick 50 ohm.m	absent	absent	absent
3 – Upper Crust	0-14 km 14 km thick 850 ohm.m	2.5-11 km 8.5 km thick 600 ohm.m	0-13 km 13 km thick 27700 ohm.m	0-14.5 km 14.5 km thick 740 ohm.m	0-16.5 km 16.5 km thick 27800 ohm.m
4 – Middle Crust	14-25 km 11 km thick 400 ohm.m	11-23 km 12 km thick 550 ohm.m	13-33 km 20 km thick 30900 ohm.m	14.5-24 km 9.5 km thick 300 ohm.m	16.5-28.5 km 12 km thick 1400 ohm.m
5 – Lower Crust	25-33 km 8 km thick 300 ohm.m	23-32 km 9 km thick 415 ohm.m	33-36.5 km 3.5 km thick 21000 ohm.m	24-37 km 13 km thick 65 ohm.m	28.5-37.5 km 9 km thick 20 ohm.m
6 – Upper Mantle	33-100 km 67 km thick 140 ohm.m	32-100 km 68 km thick 210 ohm.m	36.5-100 km 63.5 km thick 15600 ohm.m	37-100 km 63 km thick 130 ohm.m	37.5-100 km 62.5 km thick 16350 ohm.m
7 – Upper Mantle	100-150 km 50 km thick 80 ohm.m	100-150 km 50 km thick 95 ohm.m	100-250 km 150 km thick 3200 ohm.m	100-150 km 50 km thick 265 ohm.m	100-250 km 150 km thick 1850 ohm.m
	150-250 km 100 km thick 210 ohm.m	150-250 km 100 km thick 380 ohm.m		150-250 km 100 km thick 210 ohm.m	
8 – Upper Mantle	250-410 km 160 km thick 50 ohm.m	250-410 km 160 km thick 80 ohm.m	250-410 km 160 km thick 100 ohm.m	250-410 km 160 km thick 50 ohm.m	250-410 km 160 km thick 100 ohm.m
9 – Transition Zone	410-520 km 110 km thick 20 ohm.m	410-520 km 110 km thick 25 ohm.m	410-520 km 110 km thick 20 ohm.m	410-520 km 110 km thick 20 ohm.m	410-520 km 110 km thick 20 ohm.m
10 – Transition Zone	520-670 150 km thick 5.62 ohm.m	520-670 150 km thick 5.62 ohm.m	520-670 150 km thick 5.62 ohm.m	520-670 150 km thick 5.62 ohm.m	520-670 150 km thick 5.62 ohm.m
11 – Lower Mantle	670-900 km 230 km thick 1.58 ohm.m	670-900 km 230 km thick 1.58 ohm.m	670-900 km 230 km thick 1.58 ohm.m	670-900 km 230 km thick 1.58 ohm.m	670-900 km 230 km thick 1.58 ohm.m
12 – Lower Mantle	900-1000 km 100 km thick 0.89 ohm.m	900-1000 km 100 km thick 0.89 ohm.m	900-1000 km 100 km thick 0.89 ohm.m	900-1000 km 100 km thick 0.89 ohm.m	900-1000 km 100 km thick 0.89 ohm.m

Table 4.2.1 (continued, Zones 5S-6)

Layer	Zone 5S (Foreland Belt, south)	Zone 5N (Foreland Belt, north)	Zone 6 (Interior Platform)
1 – Overburden	2 m thick 70 ohm.m	10 m thick 70 ohm.m	50 m thick 70 ohm.m
2 – Sedimentary Basin	absent	absent	0-3.8 km 3.8 km thick 100 ohm.m
3 – Upper Crust	0-13 km 13 km thick 520 ohm.m	0-11.5 km 11.5 km thick 43800 ohm.m	3.8-13 km 9.2 km thick 14000 ohm.m
4 – Middle Crust	13-20.5 km 7.5 km thick 500 ohm.m	11.5-27.5 km 16 km thick 24900 ohm.m	13-19 km 6 km thick 7700 ohm.m
5 – Lower Crust	20.5-42 km 21.5 km thick 250 ohm.m	27.5-39 km 11.5 km thick 46200 ohm.m	19-39 km 20 km thick 12000 ohm.m
6 – Upper Mantle	42-100 km 58 km thick 370 ohm.m	39-100 km 61 km thick 1750 ohm.m	39-100 km 61 km thick 3300 ohm.m
7 – Upper Mantle	100-150 km 50 km thick 750 ohm.m	100-250 km 150 km thick 1950 ohm.m	100-250 km 150 km thick 700 ohm.m
	150-250 km 100 km thick 210 ohm.m		
8 – Upper Mantle	250-410 km 160 km thick 50 ohm.m	250-410 km 160 km thick 120 ohm.m	250-410 km 160 km thick 120 ohm.m
9 – Transition Zone	410-520 km 110 km thick 20 ohm.m	410-520 km 110 km thick 20 ohm.m	410-520 km 110 km thick 20 ohm.m
10 – Transition Zone	520-670 150 km thick 5.62 ohm.m	520-670 150 km thick 5.62 ohm.m	520-670 150 km thick 2.4 ohm.m
11 – Lower Mantle	670-900 km 230 km thick 1.58 ohm.m	670-900 km 230 km thick 1.58 ohm.m	670-900 km 230 km thick 1.12 ohm.m
12 – Lower Mantle	900-1000 km 100 km thick 0.89 ohm.m	900-1000 km 100 km thick 0.89 ohm.m	900-1000 km 100 km thick 0.48 ohm.m

Summary of the changes of resistivity with depth for all 12 Zones in British Columbia

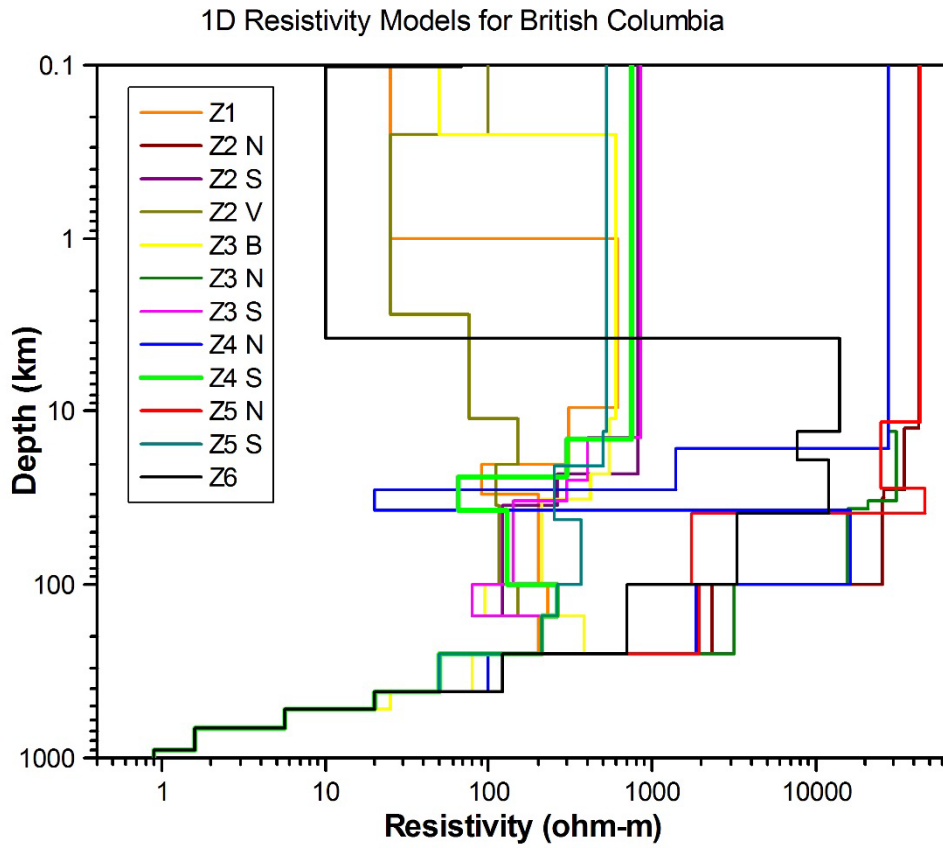


Figure 4.2.2. Variation of the resistivity for 12 different Zones (colour coded) of British Columbia. Vertical scale is depth in kilometers, horizontal scale is resistivity in Ohm·meter

Variations of surface impedance with frequency for all 12 BC resistivity models

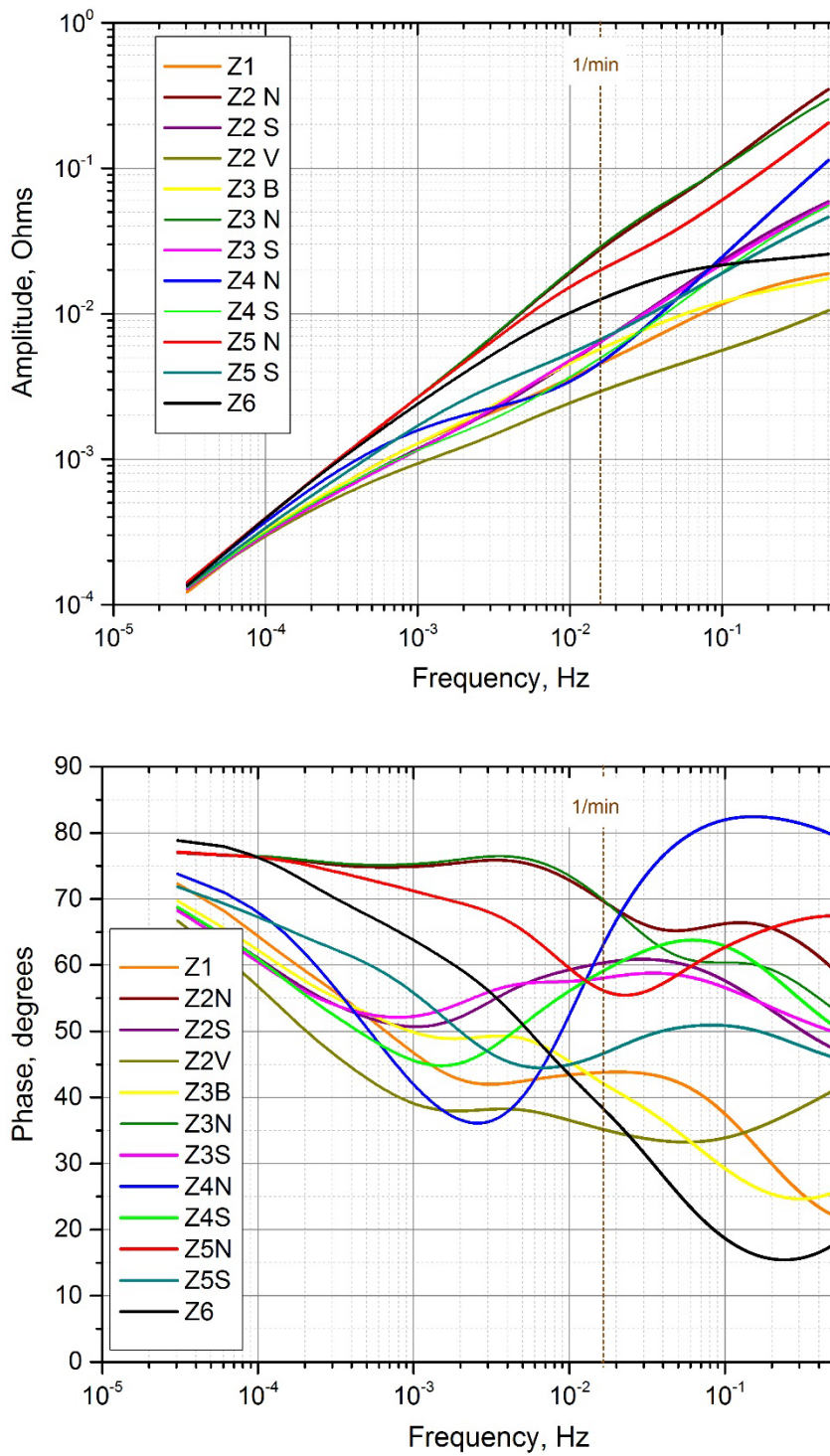


Figure 4.2.3. Variations of surface impedances (top-amplitude, bottom-phase) with frequency for 12 layered Earth models

4.3. Manitoba

Map showing the areas of different Earth's resistivity models for Manitoba is presented in Figure 4.3.1, Table 4.3.1 and Figure 4.3.2 summarize the resistivity models, and Figure 4.3.3 shows variations of surface impedance with frequency.

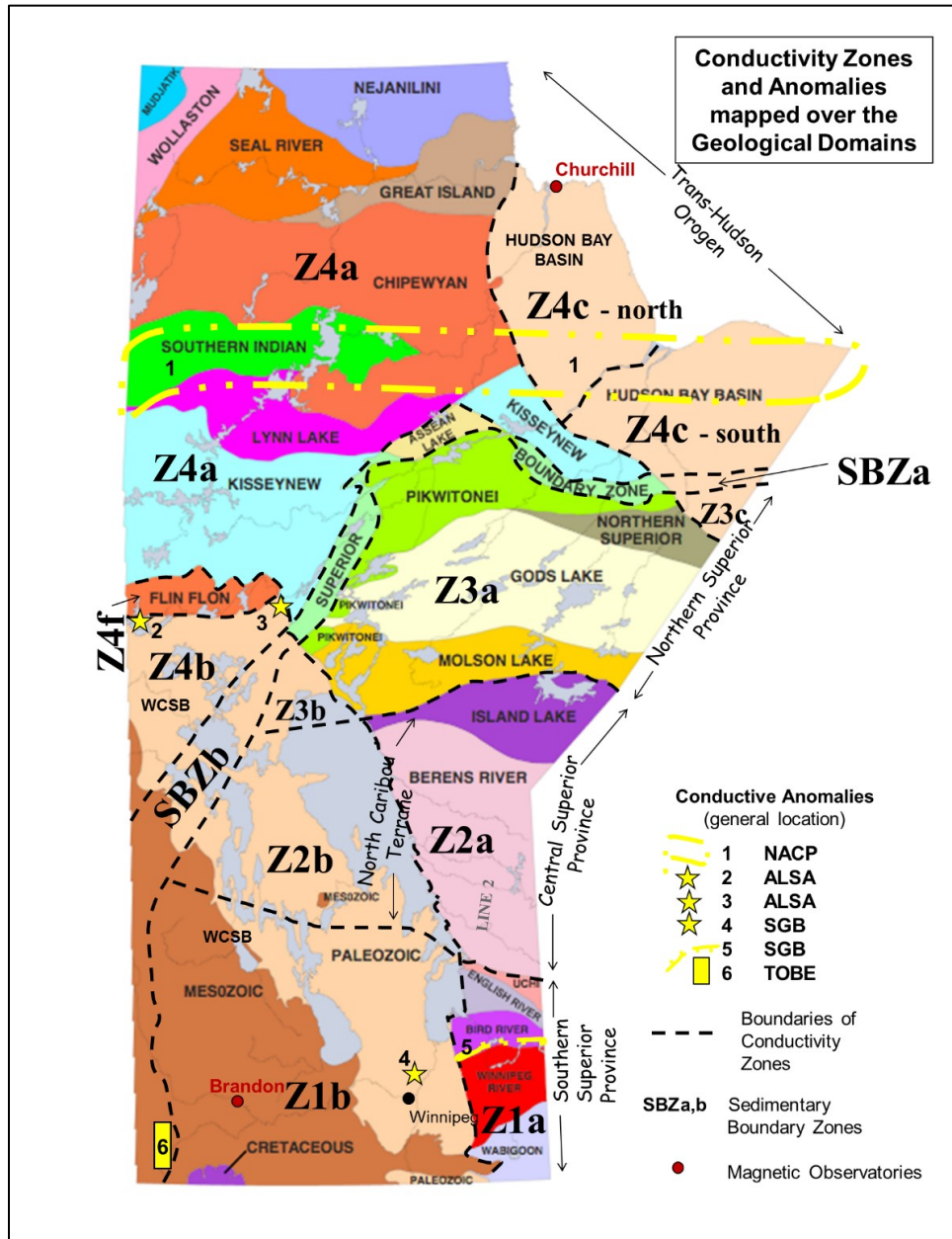


Figure 4.3.1. Map of Manitoba with the principal geological domains (www.manitoba.ca/iem/mrd/geo/exp-sup/mbgeology.html, see OF 8595, Appendix 3 for more explanations), conductivity zones, conductive anomalies and locations of two geomagnetic observatories (Brandon and Churchill).

Table 4.3.1. Summary of 1D Earth Resistivity Models for Manitoba (Zones 1-3b)

Layer	Zone 1a	Zone 1b	Zone 2a	Zone 2b	Zone 3a	Zone 3b
1 – Overburden	50 m thick 30 ohm.m	70 m thick 30 ohm.m	10 m thick 30 ohm.m	10 m thick 50 ohm.m	10 m thick 30 ohm.m	10 m thick 5 ohm.m
2 – Sedimentary Basin	absent	0-1.3 km 1.3 km thick 25 ohm.m	absent	0-0.4 km 0.4 km thick 40 ohm.m	absent	0-0.1 km 0.1 km thick 40 ohm.m
3 – Upper Crust	0-12 km 12 km thick 5500 ohm.m	1.3-10 km 8.7 km thick 3000 ohm.m	0-13 km 13 km thick 13500 ohm.m	0.4-13 km 12.6 km thick 13500 ohm.m	0-13 km 13 km thick 10000 ohm.m	0-13 km 13 km thick 10000 ohm.m
4 – Middle Crust	12-31 km 19 km thick 350 ohm.m	10-29 km 19 km thick 1450 ohm.m	13-30 km 13 km thick 35500 ohm.m	13-30 km 13 km thick 35500 ohm.m	13-28 km 15 km thick 15000 ohm.m	13-28 km 15 km thick 15000 ohm.m
5 – Lower Crust	31-39 km 8 km thick 500 ohm.m	29-43 km 14 km thick 1500 ohm.m	30-40 km 10 km thick 28000 ohm.m	30-40 km 10 km thick 28000 ohm.m	28-40 km 12 km thick 9000 ohm.m	28-40 km 12 km thick 9000 ohm.m
6 – Upper Mantle	39-100 km 61 km thick 300 ohm.m	43-100 km 57 km thick 2300 ohm.m	40-100 km 60 km thick 17000 ohm.m	40-100 km 60 km thick 17000 ohm.m	40-100 km 60 km thick 2200 ohm.m	40-100 km 60 km thick 2200 ohm.m
7 – Upper Mantle	100-250 km 150 km thick 158 ohm.m	100-250 km 150 km thick 158 ohm.m	100-250 km 150 km thick 158 ohm.m	100-250 km 150 km thick 158 ohm.m	100-250 km 150 km thick 158 ohm.m	100-250 km 150 km thick 158 ohm.m
8 – Upper Mantle	250-410 km 160 km thick 29 ohm.m	250-410 km 160 km thick 29 ohm.m	250-410 km 160 km thick 29 ohm.m	250-410 km 160 km thick 29 ohm.m	250-410 km 160 km thick 29 ohm.m	250-410 km 160 km thick 29 ohm.m
9 – Transition Zone	410-520 km 110 km thick 8 ohm.m	410-520 km 110 km thick 8 ohm.m	410-520 km 110 km thick 8 ohm.m	410-520 km 110 km thick 8 ohm.m	410-520 km 110 km thick 8 ohm.m	410-520 km 110 km thick 8 ohm.m
10 – Transition Zone	520-670 150 km thick 2.4 ohm.m	520-670 150 km thick 2.4 ohm.m	520-670 150 km thick 2.4 ohm.m	520-670 150 km thick 2.4 ohm.m	520-670 150 km thick 2.4 ohm.m	520-670 150 km thick 2.4 ohm.m
11 – Lower Mantle	670-900 km 230 km thick 1.12 ohm.m	670-900 km 230 km thick 1.12 ohm.m	670-900 km 230 km thick 1.12 ohm.m	670-900 km 230 km thick 1.12 ohm.m	670-900 km 230 km thick 1.12 ohm.m	670-900 km 230 km thick 1.12 ohm.m
12 – Lower Mantle	900-1000 km 100 km thick 0.48 ohm.m	900-1000 km 100 km thick 0.48 ohm.m	900-1000 km 100 km thick 0.48 ohm.m	900-1000 km 100 km thick 0.48 ohm.m	900-1000 km 100 km thick 0.48 ohm.m	900-1000 km 100 km thick 0.48 ohm.m

Table 4.3.1 (continued). Summary of Earth Resistivity Models for Manitoba (Zones 3c-4c)

Layer	Zone 3c	Zone 4a	Zone 4b	Zone 4c north-part	Zone 4c south-part
1 – Overburden	30 m thick 30 ohm.m	10 m thick 40 ohm.m	10 m thick 30 ohm.m	40 m thick 30 ohm.m	40 m thick 30 ohm.m
2 – Sedimentary Basin	0-0.25 km 0.25 km thick 100 ohm.m	absent	0-0.2 km 0.2 km thick 50 ohm.m	0-0.55 km 0.55 km thick 100 ohm.m	0-0.55 km 0.55 km thick 100 ohm.m
3 – Upper Crust	0-13 km 13 km thick 10000 ohm.m	0-16 km 16 km thick 9200 ohm.m	0-16 km 16 km thick 9200 ohm.m	0-16 km 16 km thick 9300 ohm.m	0-16 km 16 km thick 1000 ohm.m
4 – Middle Crust	13-28 km 15 km thick 15000 ohm.m	16-28 km 12 km thick 10400 ohm.m	16-28 km 12 km thick 10400 ohm.m	16-29 km 13 km thick 14500 ohm.m	16-29 km 13 km thick 325 ohm.m
5 – Lower Crust	28-40 km 12 km thick 9000 ohm.m	28-39 km 9 km thick 8400 ohm.m	28-39 km 9 km thick 8400 ohm.m	29-39 km 10 km thick 8400 ohm.m	29-39 km 10 km thick 325 ohm.m
6 – Upper Mantle	40-100 km 60 km thick 2200 ohm.m	39-100 km 61 km thick 500 ohm.m	39-100 km 61 km thick 500 ohm.m	39-100 km 61 km thick 500 ohm.m	39-100 km 61 km thick 350 ohm.m
7 – Upper Mantle	100-250 km 150 km thick 158 ohm.m	100-250 km 150 km thick 160 ohm.m	100-250 km 150 km thick 160 ohm.m	100-250 km 150 km thick 160 ohm.m	100-250 km 150 km thick 158 ohm.m
8 – Upper Mantle	250-410 km 160 km thick 29 ohm.m	250-410 km 160 km thick 29 ohm.m	250-410 km 160 km thick 29 ohm.m	250-410 km 160 km thick 29 ohm.m	250-410 km 160 km thick 29 ohm.m
9 – Transition Zone	410-520 km 110 km thick 8 ohm.m	410-520 km 110 km thick 8 ohm.m	410-520 km 110 km thick 8 ohm.m	410-520 km 110 km thick 8 ohm.m	410-520 km 110 km thick 8 ohm.m
10 – Transition Zone	520-670 150 km thick 2.4 ohm.m	520-670 150 km thick 2.4 ohm.m	520-670 150 km thick 2.4 ohm.m	520-670 150 km thick 2.4 ohm.m	520-670 150 km thick 2.4 ohm.m
11 – Lower Mantle	670-900 km 230 km thick 1.12 ohm.m	670-900 km 230 km thick 1.12 ohm.m	670-900 km 230 km thick 1.12 ohm.m	670-900 km 230 km thick 1.12 ohm.m	670-900 km 230 km thick 1.12 ohm.m
12 – Lower Mantle	900-1000 km 100 km thick 0.48 ohm.m	900-1000 km 100 km thick 0.48 ohm.m	900-1000 km 100 km thick 0.48 ohm.m	900-1000 km 100 km thick 0.48 ohm.m	900-1000 km 100 km thick 0.48 ohm.m

Table 4.3.1 (cont). Summary of Earth Resistivity Models for Manitoba (Zones 4f-SBZb)

Layer	Zone 4f	SBZa	SBZb
1 – Overburden	10 m thick 50 ohm.m	10 m thick 30 ohm.m	50 m thick 50 ohm.m
2 – Sedimentary Basin	absent	absent	0-1.3 km 1.3 km thick 25 ohm.m
3 – Upper Crust	0-14 km 14 km thick 8900 ohm.m	0-15 km 15 km thick 9600 ohm.m	1.3-13.5 km 12.2 km thick 8900 ohm.m
4 – Middle Crust	14-23 km 9 km thick 1100 ohm.m	15-28 km 13 km thick 12700 ohm.m	13.5-29 km 15.5 km thick 15600 ohm.m
5 – Lower Crust	23-44 km 19 km thick 1300 ohm.m	28-39.5 km 9.5 km thick 8700 ohm.m	29-39.5 km 10.5 km thick 12000 ohm.m
6 – Upper Mantle	44-100 km 56 km thick 500 ohm.m	39.5-100 km 60.5 km thick 1350 ohm.m	39.5-100 km 60.5 km thick 5500 ohm.m
7 – Upper Mantle	100-250 km 150 km thick 500 ohm.m	100-250 km 150 km thick 160 ohm.m	100-250 km 150 km thick 158 ohm.m
8 – Upper Mantle	250-410 km 160 km thick 29 ohm.m	250-410 km 160 km thick 29 ohm.m	250-410 km 160 km thick 29 ohm.m
9 – Transition Zone	410-520 km 110 km thick 8 ohm.m	410-520 km 110 km thick 8 ohm.m	410-520 km 110 km thick 8 ohm.m
10 – Transition Zone	520-670 150 km thick 2.4 ohm.m	520-670 150 km thick 2.4 ohm.m	520-670 150 km thick 2.4 ohm.m
11 – Lower Mantle	670-900 km 230 km thick 1.12 ohm.m	670-900 km 230 km thick 1.12 ohm.m	670-900 km 230 km thick 1.12 ohm.m
12 – Lower Mantle	900-1000 km 100 km thick 0.48 ohm.m	900-1000 km 100 km thick 0.48 ohm.m	900-1000 km 100 km thick 0.48 ohm.m

Summary of changes of resistivity with depth for all 14 Zones in Manitoba

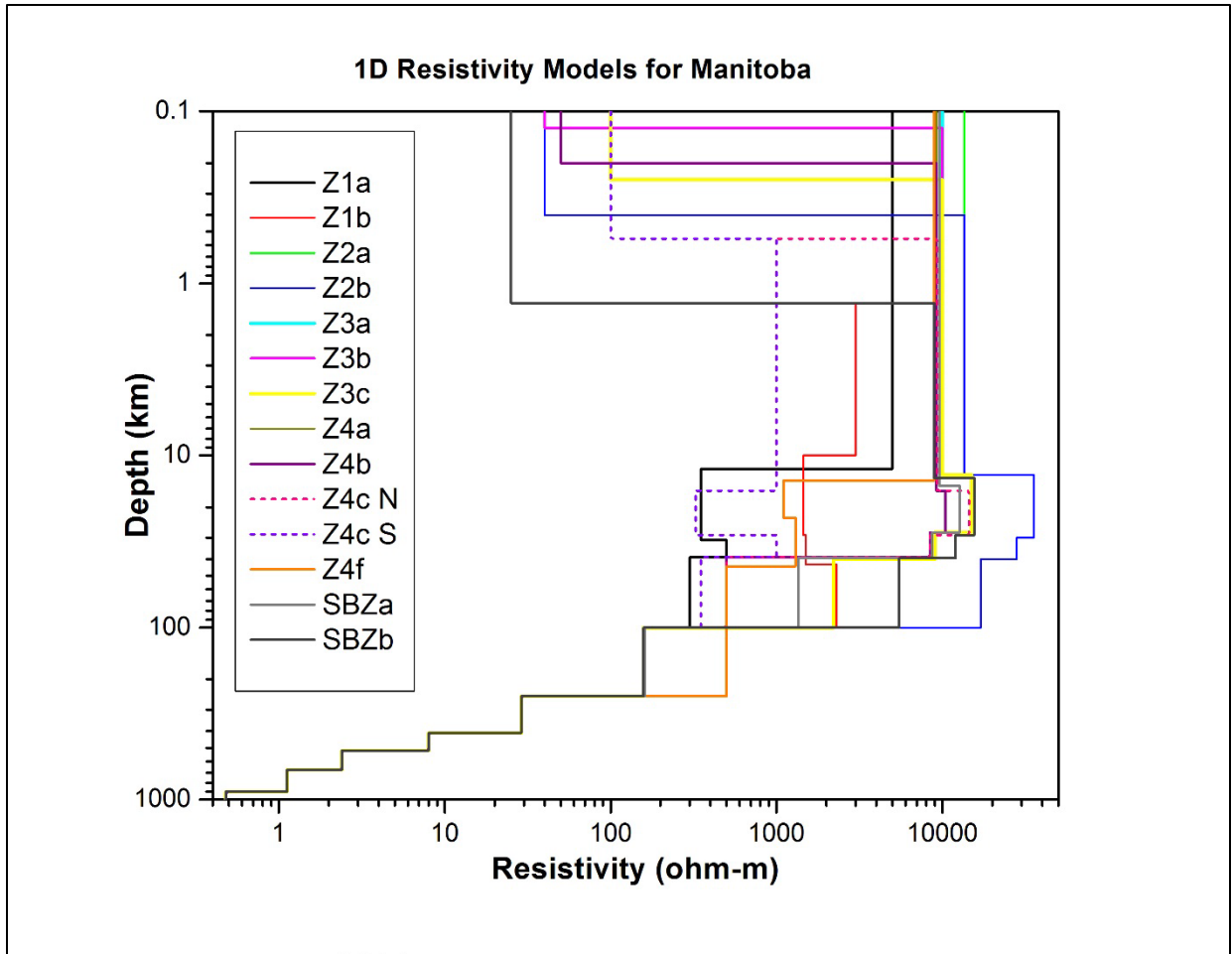


Figure 4.3.2. Variations of the resistivity for 14 different Zones (colour coded) of Manitoba. Vertical scale is depth in kilometers, horizontal scale is resistivity in Ohm-meter

Variations of surface impedance with frequency for all 14 Manitoba resistivity models

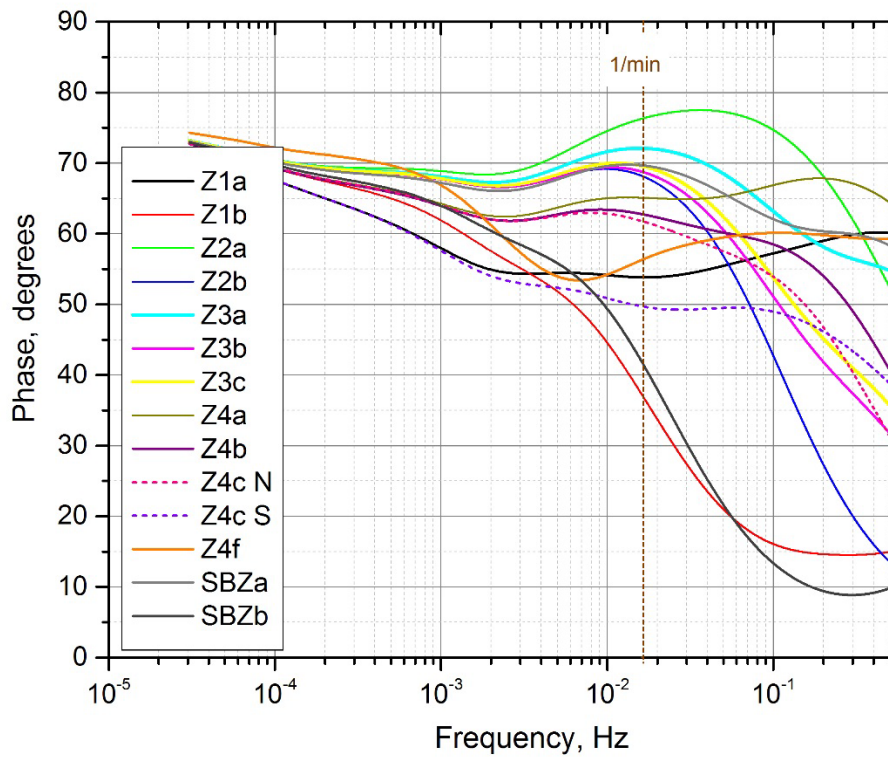
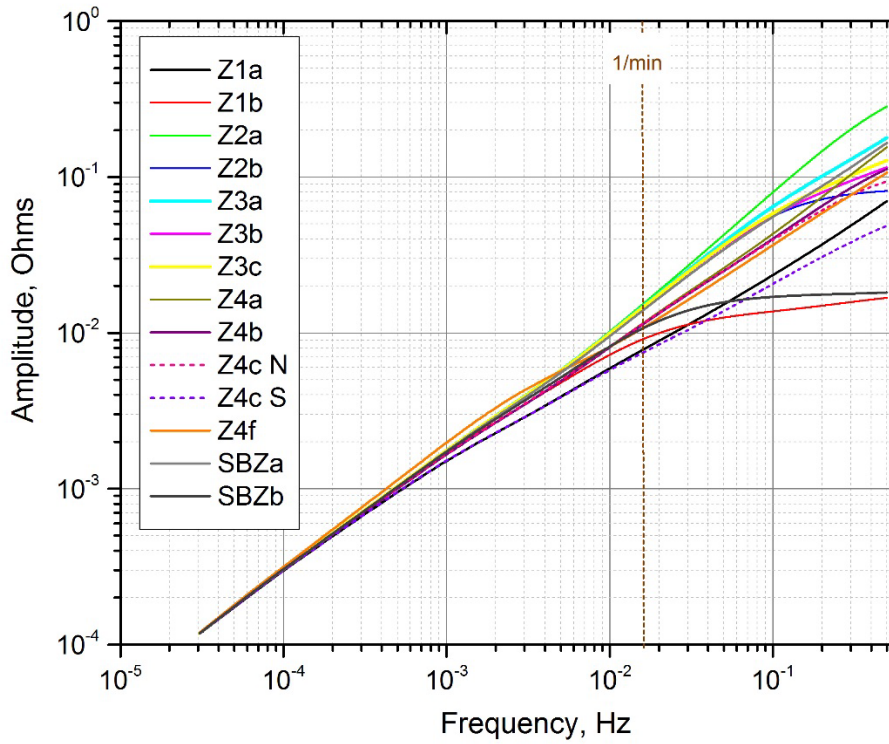


Figure 4.3.3. Variations of surface impedances (top-amplitude, bottom-phase) with frequency for 14 layered Earth models

4.4. New Brunswick

Map showing the areas of different Earth's resistivity models for New Brunswick is presented in Figure 4.4.1, Table 4.4.1 and Figure 4.4.2 summarize the resistivity models, and Figure 4.4.3 shows variations of surface impedance with frequency.

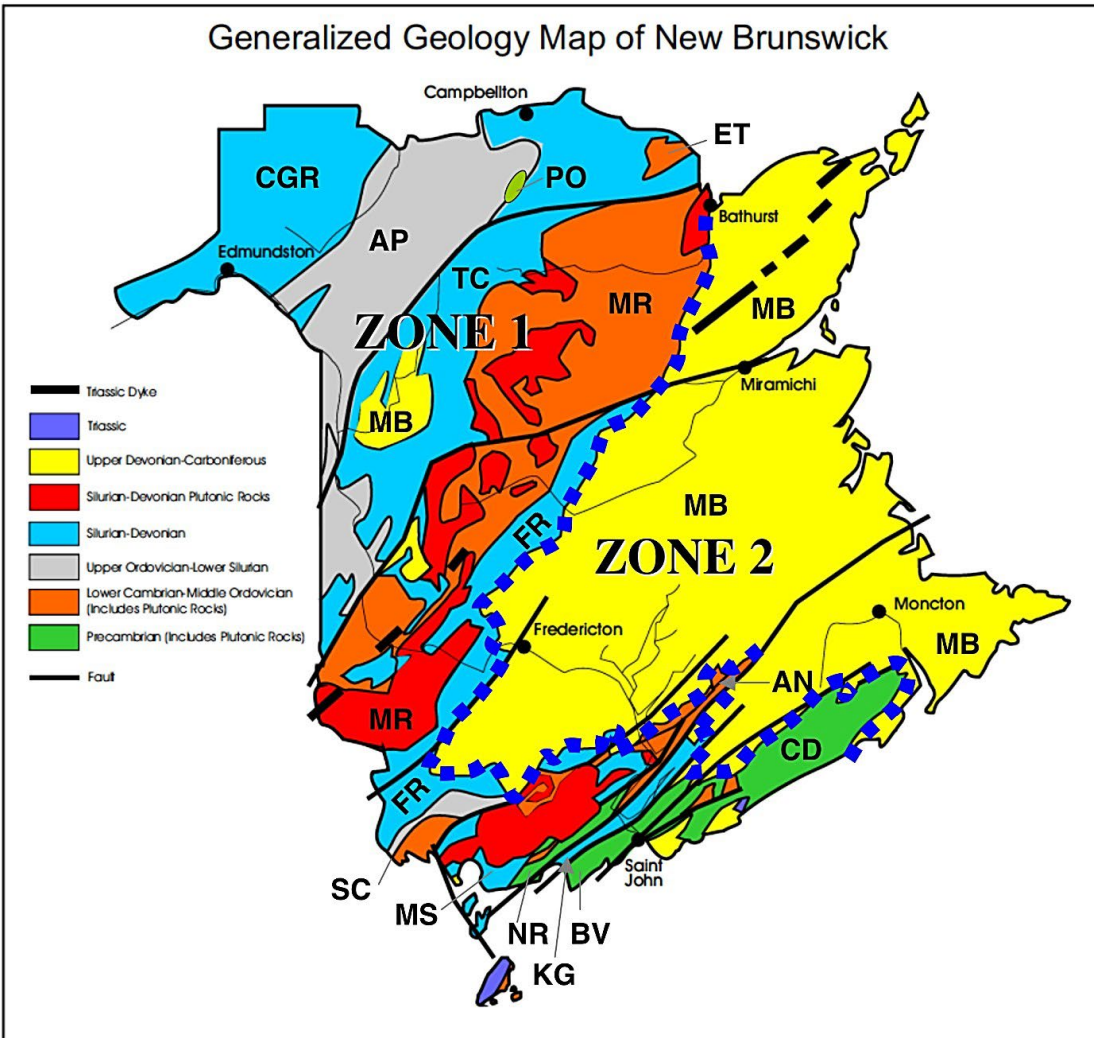


Figure 4.4.1. Location of two zones with different resistivity models (see OF 8595, Appendix 4 for more details) plotted on top of the lithotectonic zones, terranes and successor basins underlying New Brunswick (modified from [13]); abbreviations are as follows:

CD	Caledonia Terrane	MR	Miramichi Terrane
BV	Brookville Terrane	ET	Elmtree Terrane
NR	New River Terrane	PO	Popelogan Terrane
AN	Annidale Terrane	KG	Kingston
SC	St. Croix Terrane	TC	Tobique - Chaleur
FR	Fredericton Trough	AP	Aroostook - Perce
MS	Mascarene	MB	Maritimes Basin
CGR	Connecticut Valley - Gaspé / Restigouche		

Table 4.4.1 Summary of 1D Earth Resistivity Models for New Brunswick

Layer	Zone 1	Zone 2	Layer	Zone 1	Zone 2
1 – Overburden	2 m thick 25 ohm.m	2 m thick 25 ohm.m	7 – Upper Mantle	100-250 km 150 km thick 2800 ohm.m	100-250 km 150 km thick 1700 ohm.m
2 – Sedimentary Basin	absent	0-1 km 1 km thick 150 ohm.m	8 – Upper Mantle	250-410 km 160 km thick 29 ohm.m	250-410 km 160 km thick 29 ohm.m
3 – Upper Crust	0-9 km 9 km thick 550 ohm.m	1-9 km 8 km thick 1000 ohm.m	9 – Transition Zone	410-520 km 110 km thick 8 ohm.m	410-520 km 110 km thick 8 ohm.m
4 – Middle Crust	9-30 km 21 km thick 2800 ohm.m	9-30 km 21 km thick 2000 ohm.m	10 – Transition Zone	520-670 km 160 km thick 2.4 ohm.m	520-670 km 160 km thick 2.4 ohm.m
5 – Lower Crust	30-39 km 9 km thick 2000 ohm.m	30-39 km 9 km thick 1600 ohm.m	11 – Lower Mantle	670-900 km 230 km thick 1.12 ohm.m	670-900 km 230 km thick 1.12 ohm.m
6 – Upper Mantle	39-100 km 61 km thick 500 ohm.m	39-100 km 61 km thick 500 ohm.m	12 – Lower Mantle	900-1000 km 100 km thick 0.47 ohm.m	900-1000 km 100 km thick 0.47 ohm.m

Summary of changes of resistivity with depth for both Zones in New Brunswick

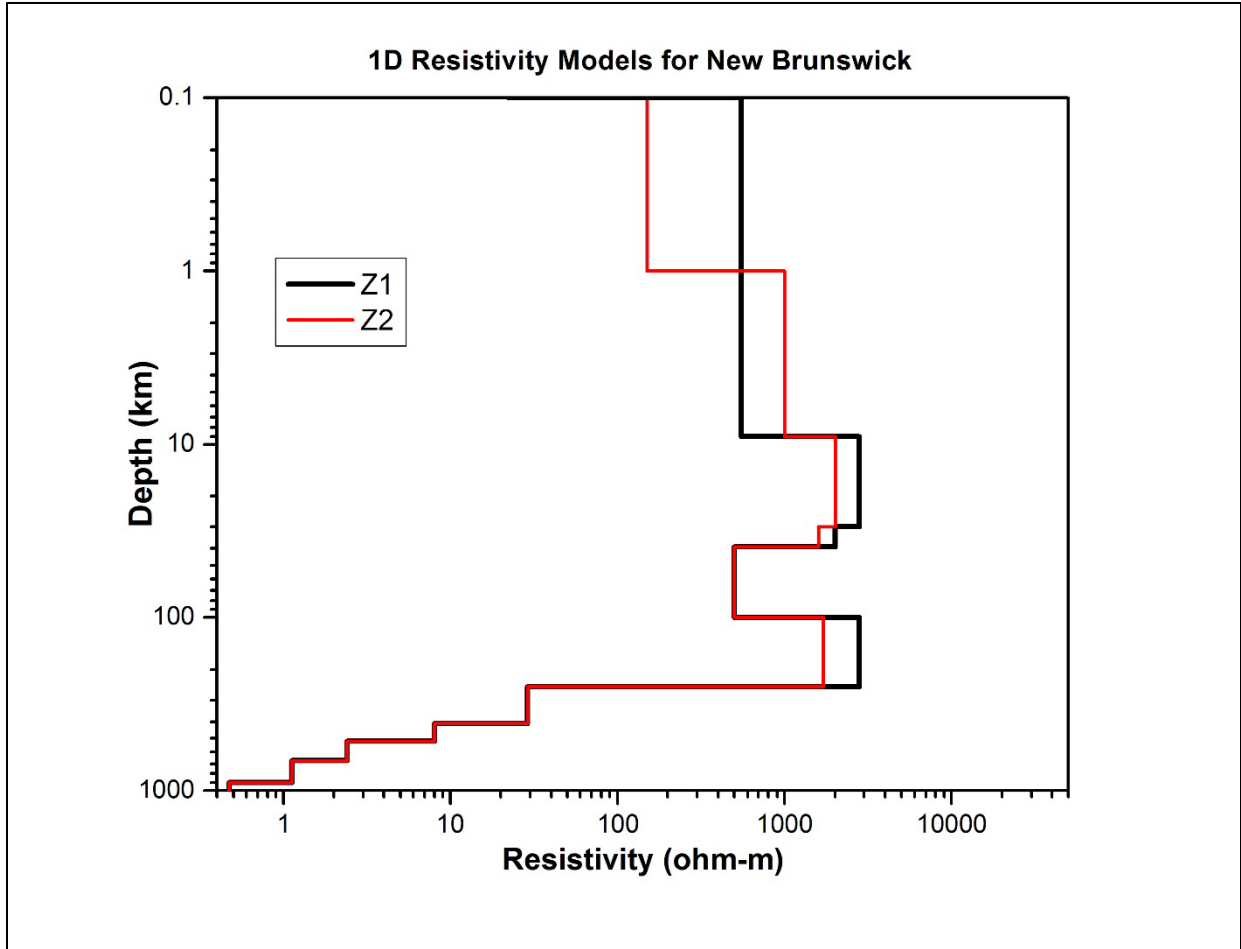


Figure 4.4.2. Variation of the resistivity for two identified Zones (colour coded) of New Brunswick. Vertical scale is depth in kilometers, horizontal scale is resistivity in Ohm·meter

Variations of surface impedance with frequency for all New Brunswick resistivity models

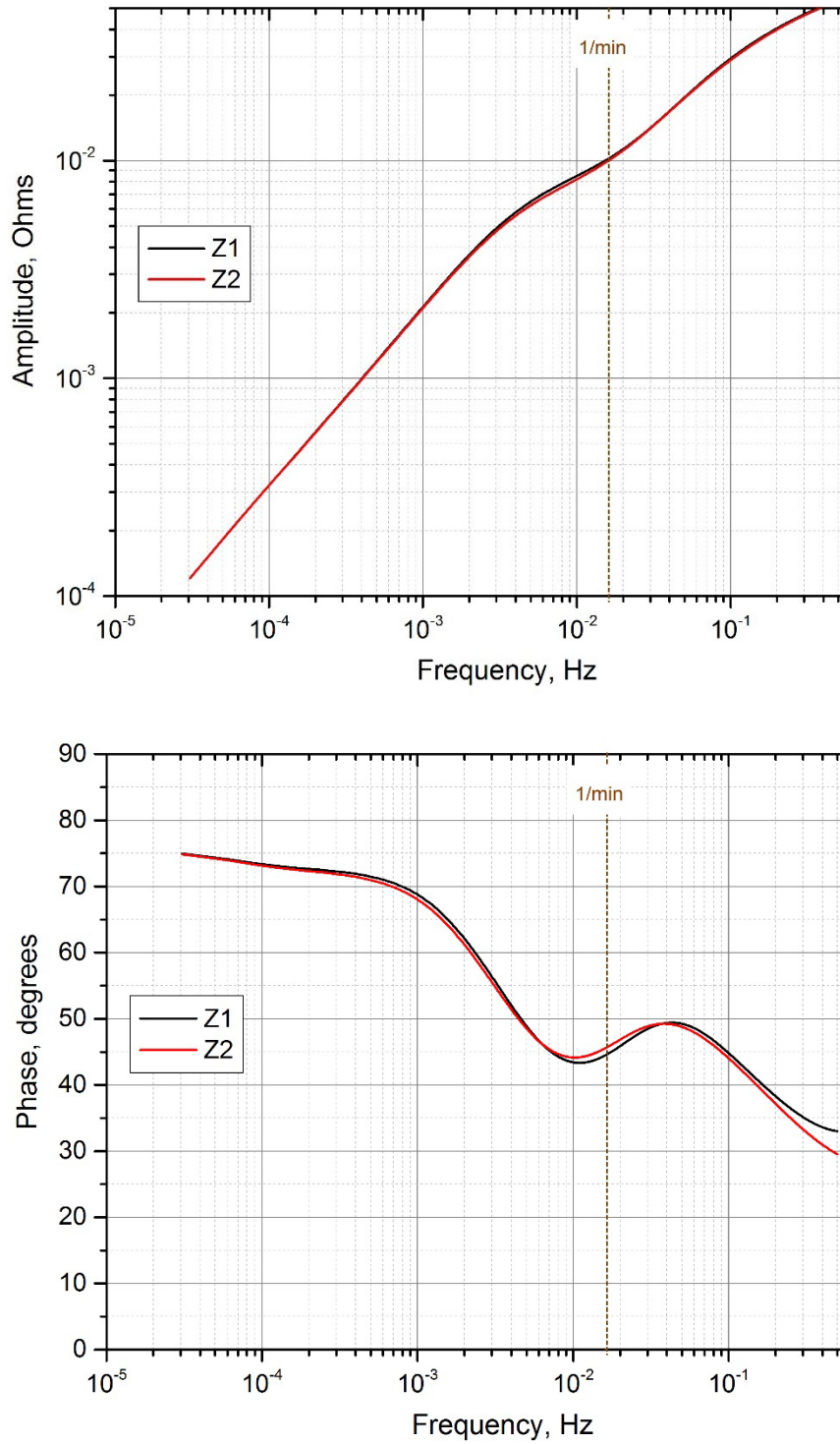


Figure 4.4.3. Variations of surface impedances (top-amplitude, bottom-phase) with frequency for all layered Earth models

4.5. Newfoundland & Labrador (island only)

Map showing the areas of different Earth's resistivity models for Island of Newfoundland is presented in Figure 4.5.1, Table 4.5.1 and Figure 4.5.2 summarize the resistivity models, and Figure 4.5.3 shows variations of surface impedance with frequency.

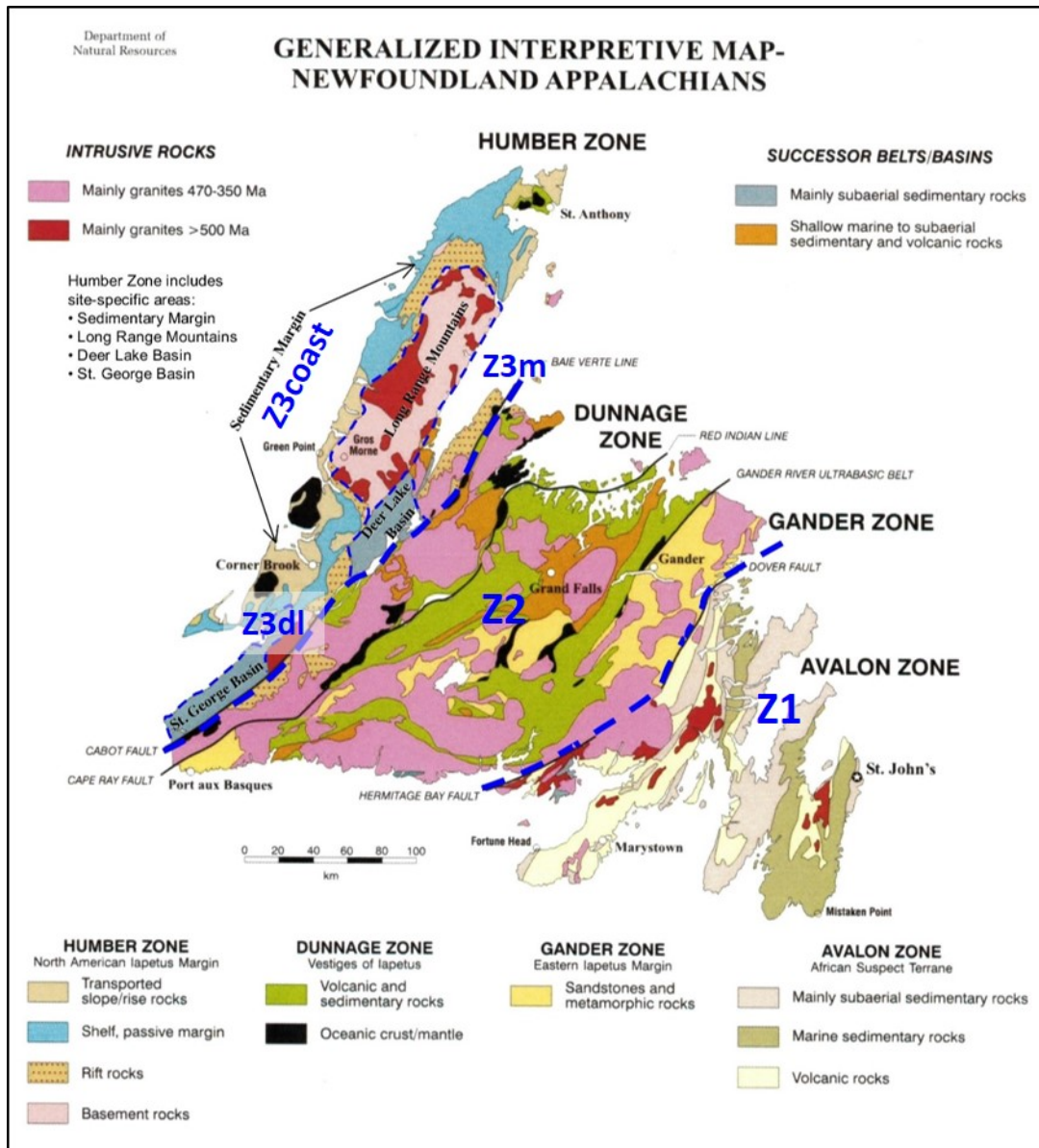


Figure 4.5.1. Areas of coverage for the three major 1D Earth models (Zone 3 is subdivided into 3 sub-zones) and tectonic terranes, Avalon Zone, Dunnage-Gander Zone and Humber Zone, plotted on top of map showing major rock types and tectonic terranes underlying island of Newfoundland [14]. See OF 8595, Appendix 5 for more details.

Table 4.5.1 Summary of 1D Earth Resistivity Models for Island of Newfoundland

Layer	Avalon Zone	Dunnage-Gander Zone	Humber Zone coast	Humber Zone Deer Lake Basin	Humber Zone Long Range Mountains
1 – Overburden	City of St. John’s 2 m thick, 100 ohm.m Outside 8m thick, 100 ohm.m	5 m thick 100 ohm.m	15 m thick 100 ohm.m	15 m thick 100 ohm.m	15 m thick 100 ohm.m
2 – Sedimentary Basin	absent	absent	absent	absent	absent
3 – Upper Crust	<i>Upper Sublayer</i> 3 km thick 30 ohm.m	8 km thick 27000 ohm.m	<i>3a. Sedimentary Margin</i> 4 km thick 250 ohm.m	<i>3a. Sedimentary Margin</i> 2.5 km thick 10 ohm.m	<i>3a. Sedimentary Margin</i> 4 km thick 16000 ohm.m
	<i>Lower Sublayer</i> 9 km thick 2700 ohm.m		<i>3b. Crystalline Basement</i> 3 km thick 16000 ohm.m	<i>3b. Crystalline Basement</i> 4.5 km thick 16000 ohm.m	<i>3b. Crystalline Basement</i> 3 km thick 16000 ohm.m
4 – Middle Crust	11 km thick, 25 ohm.m	14 km thick 17000 ohm.m	16 km thick 100 ohm.m	16 km thick 100 ohm.m	16 km thick 100 ohm.m
5 – Lower Crust	11 km thick 15 ohm.m	14 km thick 610 ohm.m	14 km thick 150 ohm.m	14 km thick 150 ohm.m	14 km thick 150 ohm.m
6 – Upper Mantle	66 km thick 200 ohm.m	64 km thick 375 ohm.m	63 km thick 330 ohm.m	63 km thick 330 ohm.m	63 km thick 330 ohm.m
7 – Upper Mantle	150 km thick 158 ohm.m	150 km thick 158 ohm.m	150 km thick 158 ohm.m	150 km thick 158 ohm.m	150 km thick 158 ohm.m
8 – Upper Mantle	160 km thick 29 ohm.m	160 km thick 29 ohm.m	160 km thick 29 ohm.m	160 km thick 29 ohm.m	160 km thick 29 ohm.m
9 – Transition Zone	110 km thick 8 ohm.m	110 km thick 8 ohm.m	110 km thick 8 ohm.m	110 km thick 8 ohm.m	110 km thick 8 ohm.m
10 – Transition Zone	150 km thick 2.4 ohm.m	150 km thick 2.4 ohm.m	150 km thick 2.4 ohm.m	150 km thick 2.4 ohm.m	150 km thick 2.4 ohm.m
11 – Lower Mantle	230 km thick 1.12 ohm.m	230 km thick 1.12 ohm.m	230 km thick 1.12 ohm.m	230 km thick 1.12 ohm.m	230 km thick 1.12 ohm.m
12 – Lower Mantle	100 km thick 0.47 ohm.m	100 km thick 0.47 ohm.m	100 km thick 0.47 ohm.m	100 km thick 0.47 ohm.m	100 km thick 0.47 ohm.m

Changes of resistivity with depth for all Zones, Island of Newfoundland

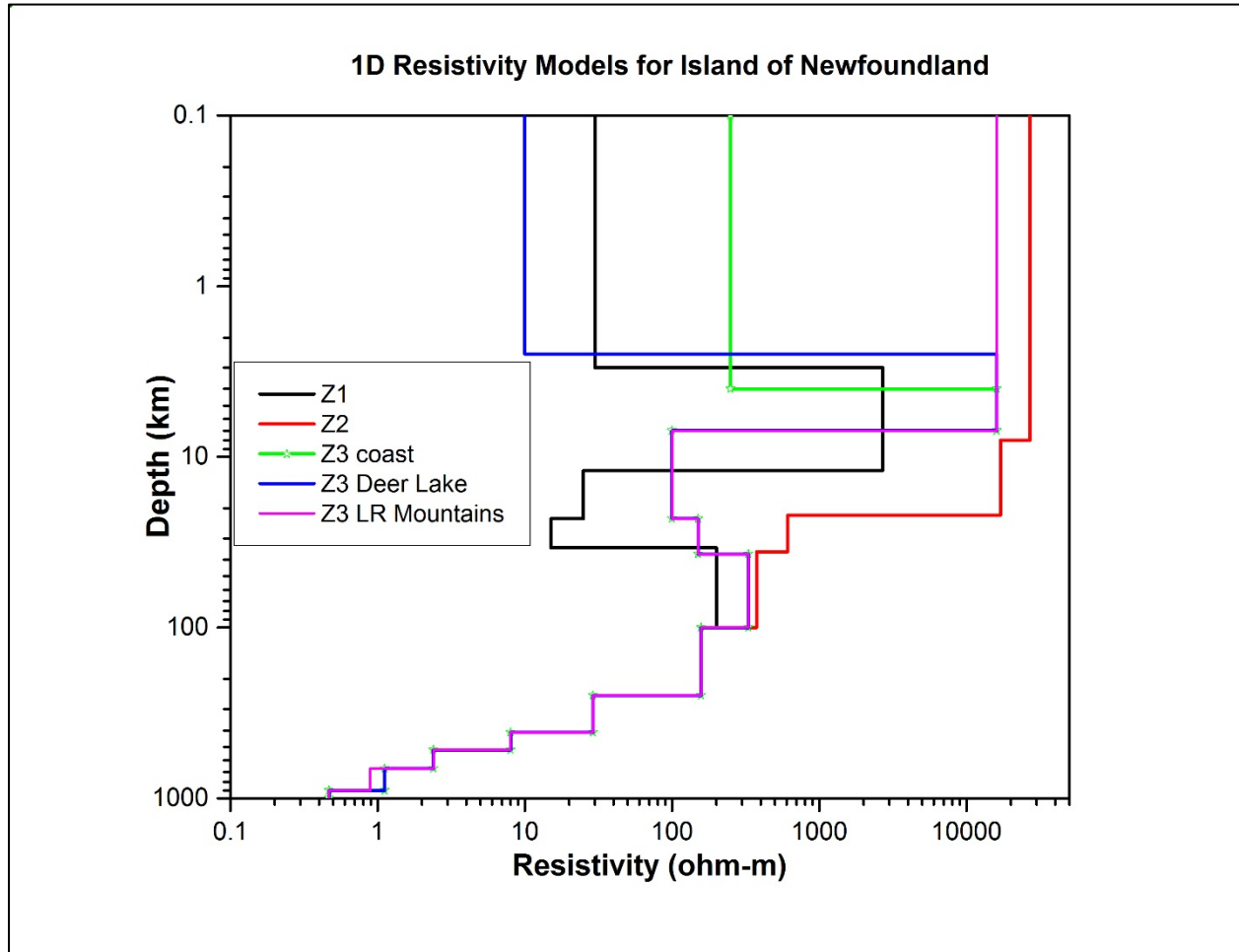


Figure 4.5.2. Variation of the resistivity for 5 identified Zones (colour coded) of Island of Newfoundland. Vertical scale is depth in kilometers, horizontal scale is resistivity in Ohm·meter

Variations of surface impedance with frequency for Island of Newfoundland resistivity models

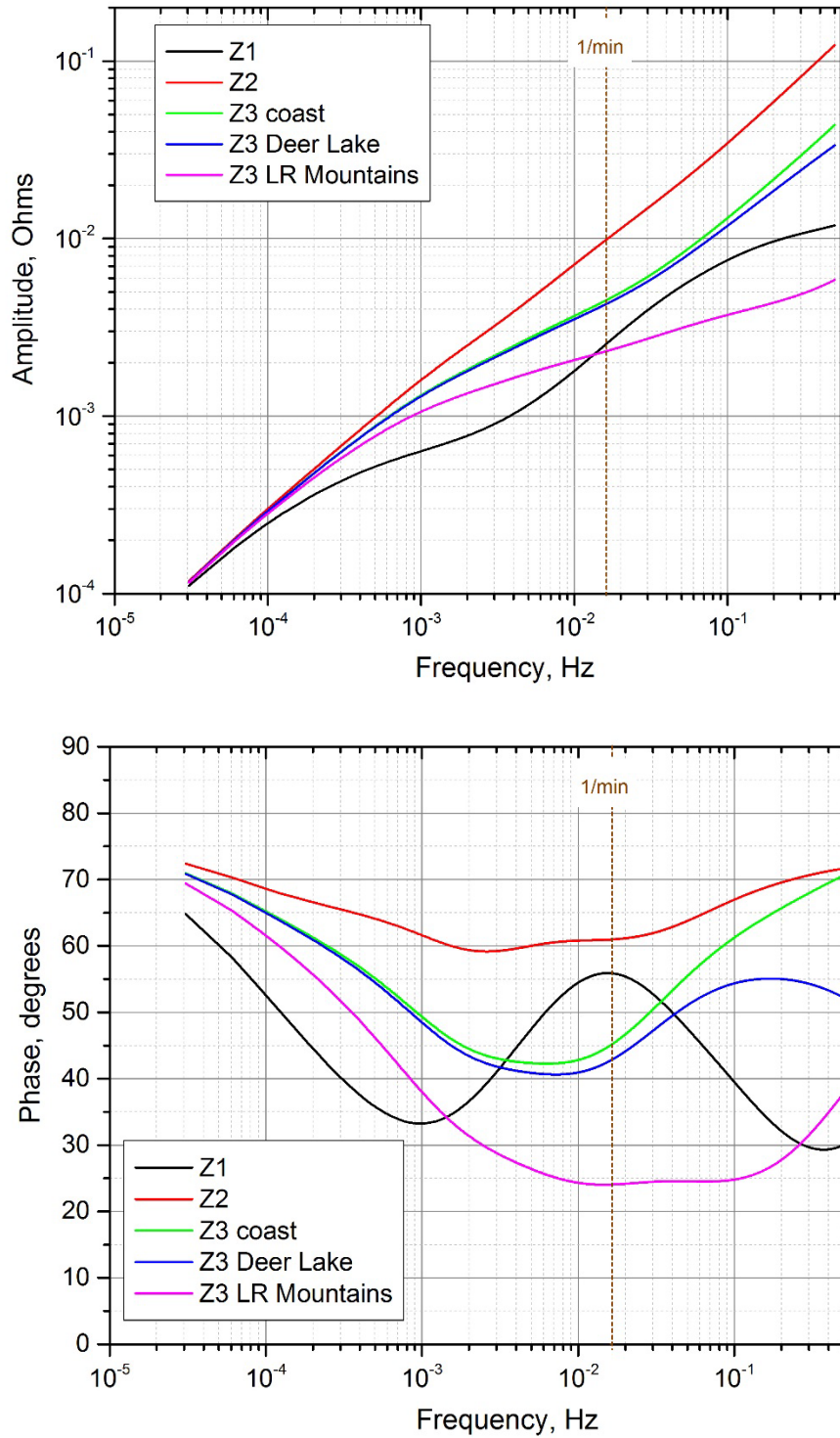


Figure 4.5.3. Variations of surface impedances (top-amplitude, bottom-phase) with frequency for all layered Earth models

4.6. Nova Scotia

Map showing the areas of different Earth's resistivity models for Nova Scotia is presented in Figure 4.6.1, Table 4.6.1 and Figure 4.6.2 summarize the resistivity models, and Figure 4.6.3 shows variations of surface impedance with frequency.

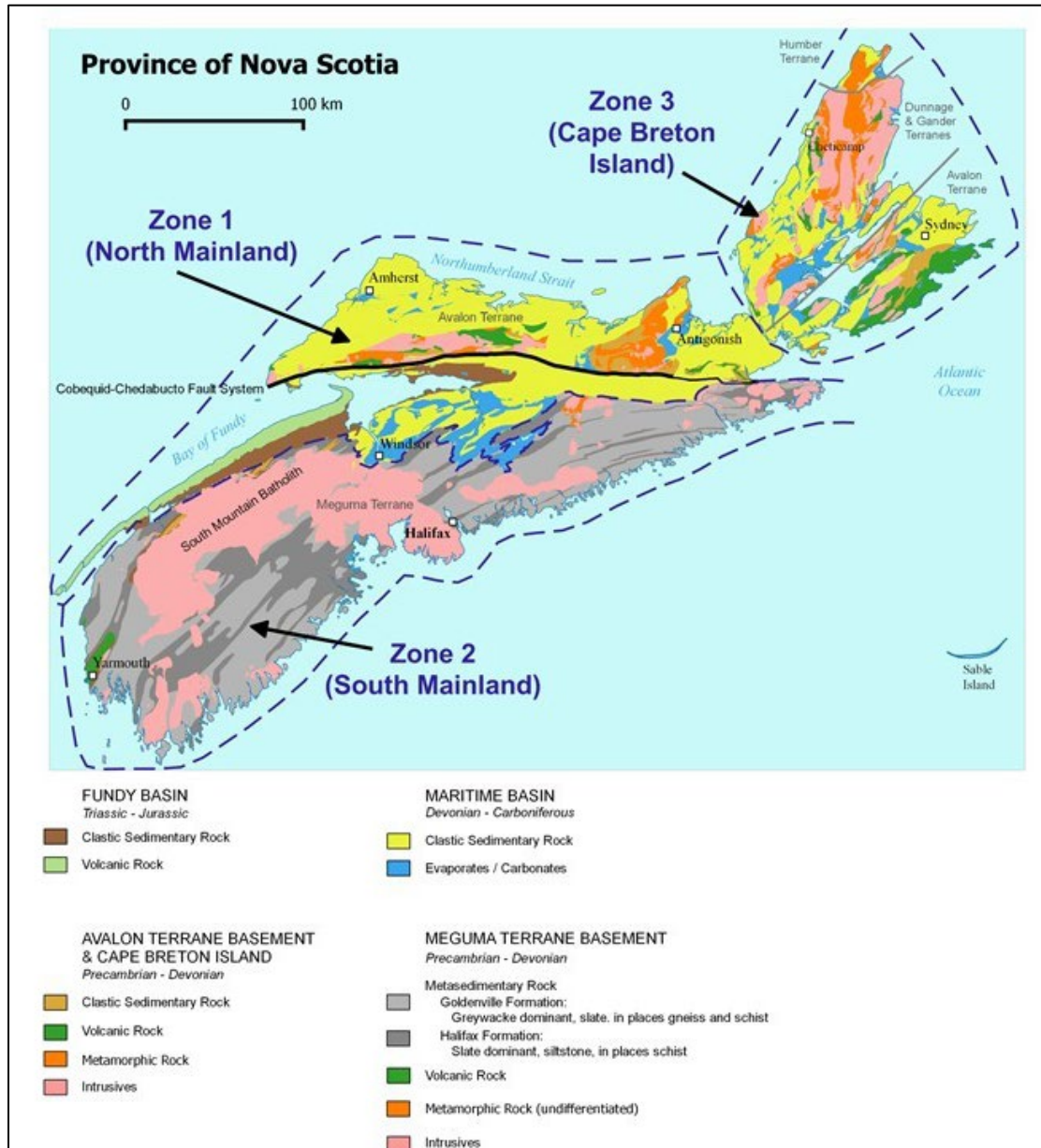


Figure 4.6.1. Areas of coverage for the three major 1D Earth models mapped on top of bedrock geology and lithotectonic terranes and successor basins underlying Nova Scotia (*modified from [15]*). See OF 8595, Appendix 6 for more details

Table 4.6.1 Summary of 1D Earth Resistivity Models for Nova Scotia

Layer	Zone 1	Zone 2	Zone 3
1 – Overburden	10 m thick 25 ohm.m	20 m thick 25 ohm.m	7 m thick 25 ohm.m
2 – Sedimentary Basin	0-2 km 2 km thick 150 ohm.m	absent	0-1.5 km 0.75 km thick 150 ohm.m
3 – Upper Crust	2-12 km 10 km thick 1000 ohm.m	2-12 km 10 km thick 1000 ohm.m	0.75-12 km 11.25 km thick 8000 ohm.m
4 – Middle Crust	12-26 km 14 km thick 1000 ohm.m	12-26 km 14 km thick 1000 ohm.m	12-26 km 14 km thick 5000 ohm.m
5 – Lower Crust	26-44 km 18 km thick 1000 ohm.m	26-44 km 18 km thick 1000 ohm.m	26-44 km 18 km thick 625 ohm.m
6 – Upper Mantle	44-100 km 56 km thick 325 ohm.m	44-100 km 56 km thick 325 ohm.m	44-100 km 56 km thick 450 ohm.m
7 – Upper Mantle	100-250 km 150 km thick 2000 ohm.m	100-250 km 150 km thick 2000 ohm.m	100-250 km 150 km thick 750 ohm.m
8 – Upper Mantle	250-410 km 160 km thick 29 ohm.m	250-410 km 160 km thick 29 ohm.m	250-410 km 160 km thick 29 ohm.m
9 – Transition Zone	410-520 km 110 km thick 8 ohm.m	410-520 km 110 km thick 8 ohm.m	410-520 km 110 km thick 8 ohm.m
10 – Transition Zone	520-670 km 160 km thick 2.4 ohm.m	520-670 km 160 km thick 2.4 ohm.m	520-670 km 160 km thick 2.4 ohm.m
11 – Lower Mantle	670-900 km 230 km thick 1.12 ohm.m	670-900 km 230 km thick 1.12 ohm.m	670-900 km 230 km thick 1.12 ohm.m
12 – Lower Mantle	900-1000 km 100 km thick 0.47 ohm.m	900-1000 km 100 km thick 0.47 ohm.m	900-1000 km 100 km thick 0.47 ohm.m

Changes of resistivity with depth for all Zones, Nova Scotia

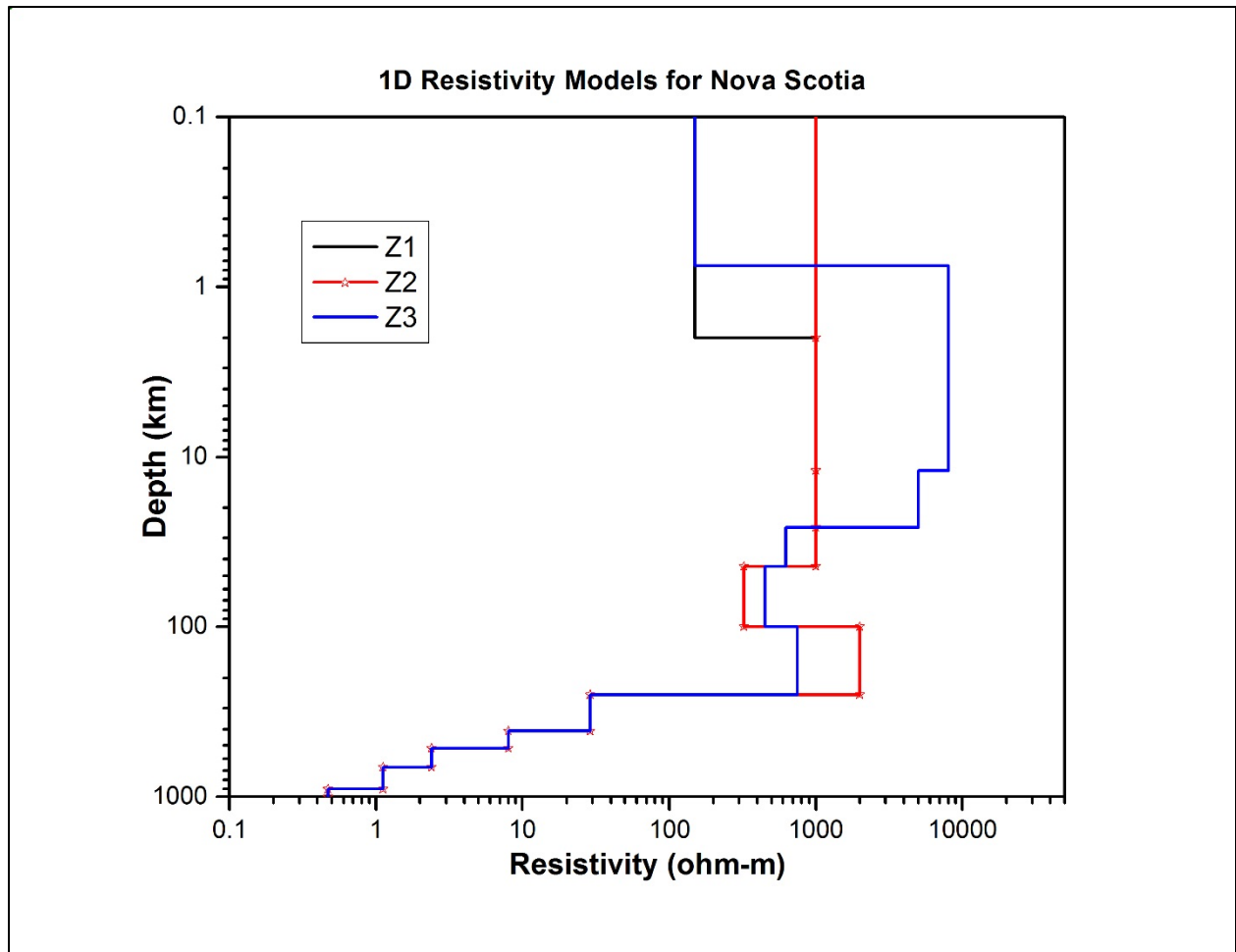


Figure 4.6.2. Variation of the resistivity for 3 identified Zones (colour coded) of Nova Scotia. Vertical scale is depth in kilometers, horizontal scale is resistivity in Ohm·meter

Variations of surface impedance with frequency for all Nova Scotia resistivity models

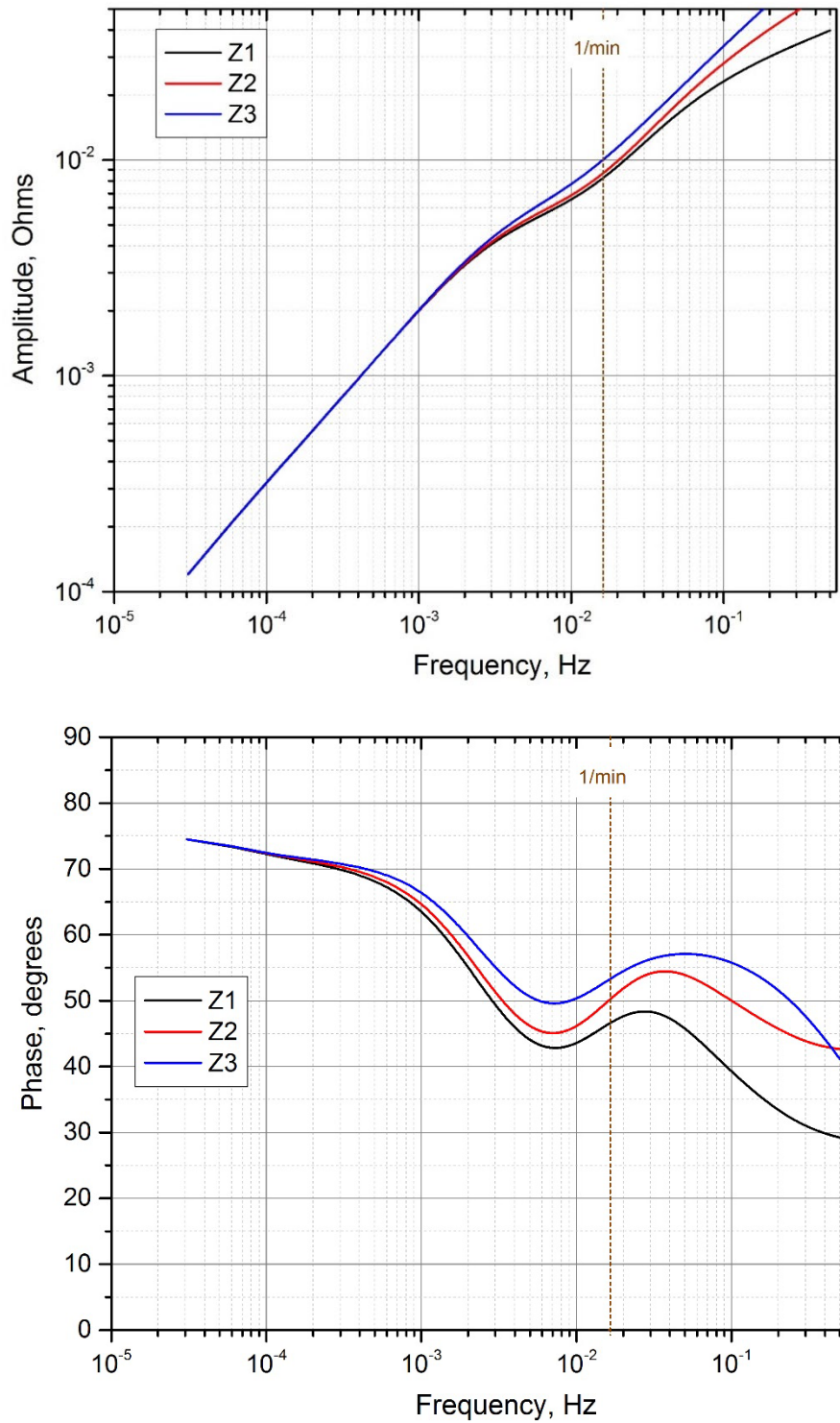


Figure 4.6.3. Surface impedance for NS models (top-amplitude, bottom- phase). Frequencies are corresponding to periods from 1 day to 1 second

4.7. Ontario

Map showing the areas of different Earth's resistivity models for Ontario is presented in Figure 4.7.1, Table 4.7.1 and Figure 4.7.2 summarize the resistivity models, and Figure 4.7.3 shows variations of surface impedance with frequency.



Figure 4.7.1. Detailed Earth resistivity zones of Ontario mapped over Geological Provinces. See OF 8595, Appendix 7 for more details.

Table 4.7.1 Summary of 1D Earth Resistivity Models for Ontario (Zones 1 to 3a)

Layer	Zone 1 Western St. Lawrence Platform	Zone 2 Central St. Lawrence Platform	Zone 3 Grenville	Zone 3a Grenville Front Tectonic Zone
1 – Overburden	100 m 100 ohm.m	< 50 m 25 ohm.m	3 m 100 ohm.m	3 m 100 ohm.m
2 – Sedimentary Basin	1 km 130 ohm.m	0.9 km 250 ohm.m	absent	absent
3 – Upper Crust	10 km 5000 ohm.m	9.1 km 5000 ohm.m	15 km 6000 ohm.m	17 km 50000 ohm.m
4 – Middle Crust	14 km 125 ohm.m	15 km 100 ohm.m	17 km 275 ohm.m	10 km thick 5000 ohm.m
5 – Lower Crust	16 km 300 ohm.m	15 km 125 ohm.m	13 km 500 ohm.m	13 km thick 300 ohm.m
6 – Upper Mantle	59 km 300 ohm.m	60 km 200 ohm.m	60 km 300 ohm.m	<i>Depth 40-80 km</i> 40 km thick 500 ohm.m <i>Depth 80-100 km</i> 20 km thick 80 ohm.m
7 – Upper Mantle	100 km 158 ohm.m	100 km 158 ohm.m	100 km 158 ohm.m	100 km 158 ohm.m
8 – Upper Mantle	160 km 29 ohm.m	160 km 29 ohm.m	160 km 29 ohm.m	160 km 29 ohm.m
9 – Transition Zone	110 km 8 ohm.m	110 km 8 ohm.m	110 km 8 ohm.m	110 km 8 ohm.m
10 – Transition Zone	150 km 2.4 ohm.m	150 km 2.4 ohm.m	150 km 2.4 ohm.m	150 km 2.4 ohm.m
11 – Lower Mantle	230 km 0.89 ohm.m	230 km 0.89 ohm.m	230 km 0.89 ohm.m	230 km 0.89 ohm.m
12 – Lower Mantle	100 km 0.47 ohm.m	100 km 0.47 ohm.m	100 km 0.47 ohm.m	100 km 0.47 ohm.m

Table 4.7.1 (continued) Summary of 1D Earth Resistivity Models for Ontario (Zones 4 to 6)

Layer	Zone 4 Superior eastern	Zone 4a Superior Kapuskasig Uplift	Zone 5a Superior western south of NCS	Zone 5b Superior western north of NCS	Zone 6 Hudson Bay Lowlands
1 – Overburden	<i>Southern 2/3</i> 1 m 100 ohm.m <i>Northern 1/3</i> 50 m 30 ohm.m	** includes glacial drift & weathered bedrock ** 0.3 km 3000 ohm.m	1 m 60 ohm.m	25 m 60 ohm.m	40 m 30 Ohm.m
2 – Sedimentary Basin	absent	absent	absent	absent	250 m 50 Ohm.m
3 – Upper Crust	15 km 25000 ohm.m	15 km 40000 ohm.m	13 km 7500 ohm.m	13 km 50000 ohm.m	13 km 16000 ohm.m
4 – Middle Crust	12 km 125 ohm.m	20 km 4000 ohm.m	17 km 125 ohm.m	17 km 10500 ohm.m	13 km 5500 ohm.m
5 – Lower Crust	10 km 500 ohm.m	215 km 900 ohm.m	10 km 275 ohm.m	10 km 6500 ohm.m	13 km 6000 ohm.m
6 – Upper Mantle	60 km 250 ohm.m		60 km 600 ohm.m	60 km 3000 ohm.m	62 km 2500 ohm.m
7 – Upper Mantle	100 km 158 ohm.m	750 km 100 ohm.m	100 km 158 ohm.m	100 km 158 ohm.m	150 km 210 ohm.m
8 – Upper Mantle	160 km 29 ohm.m		160 km 29 ohm.m	160 km 29 ohm.m	160 km 50 ohm.m
9 – Transition Zone	110 km 8 ohm.m		110 km 8 ohm.m	110 km 8 ohm.m	110 km 20 ohm.m
10 – Transition Zone	150 km 2.4 ohm.m		150 km 2.4 ohm.m	150 km 2.4 ohm.m	150 km 5.6 ohm.m
11 – Lower Mantle	230 km 0.89 ohm.m		230 km 0.89 ohm.m	230 km 0.89 ohm.m	230 km 1.58 ohm.m
12 – Lower Mantle	100 km 0.47 ohm.m		100 km 0.47 ohm.m	100 km 0.47 ohm.m	100 km 1.12 ohm.m

Changes of resistivity with depth for all Zones, Ontario

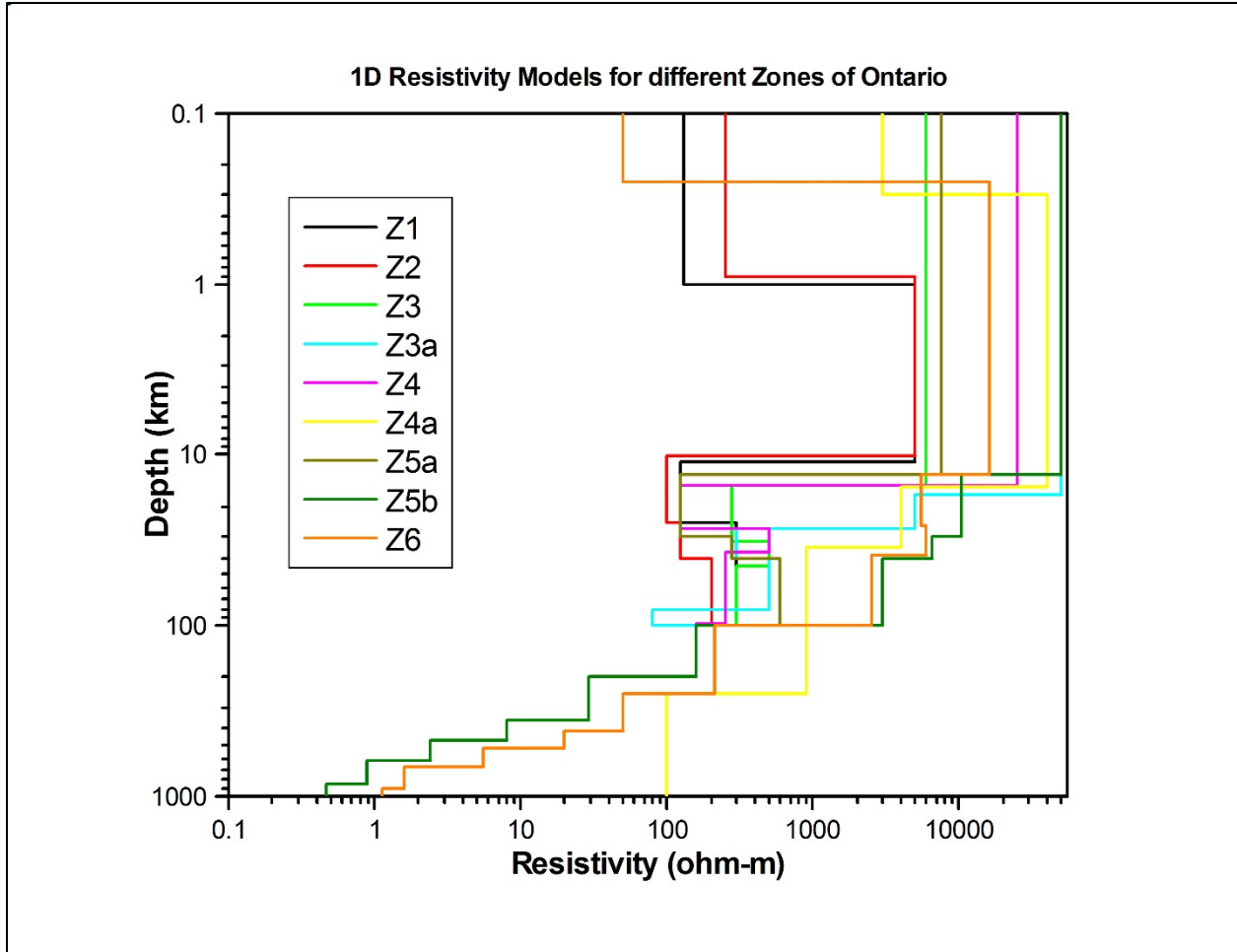


Figure 4.7.2. Variation of the resistivity for 9 identified Zones (colour coded) of Ontario. Vertical scale is depth in kilometers, horizontal scale is resistivity in Ohm·meter

Variations of surface impedance with frequency for all Ontario resistivity models

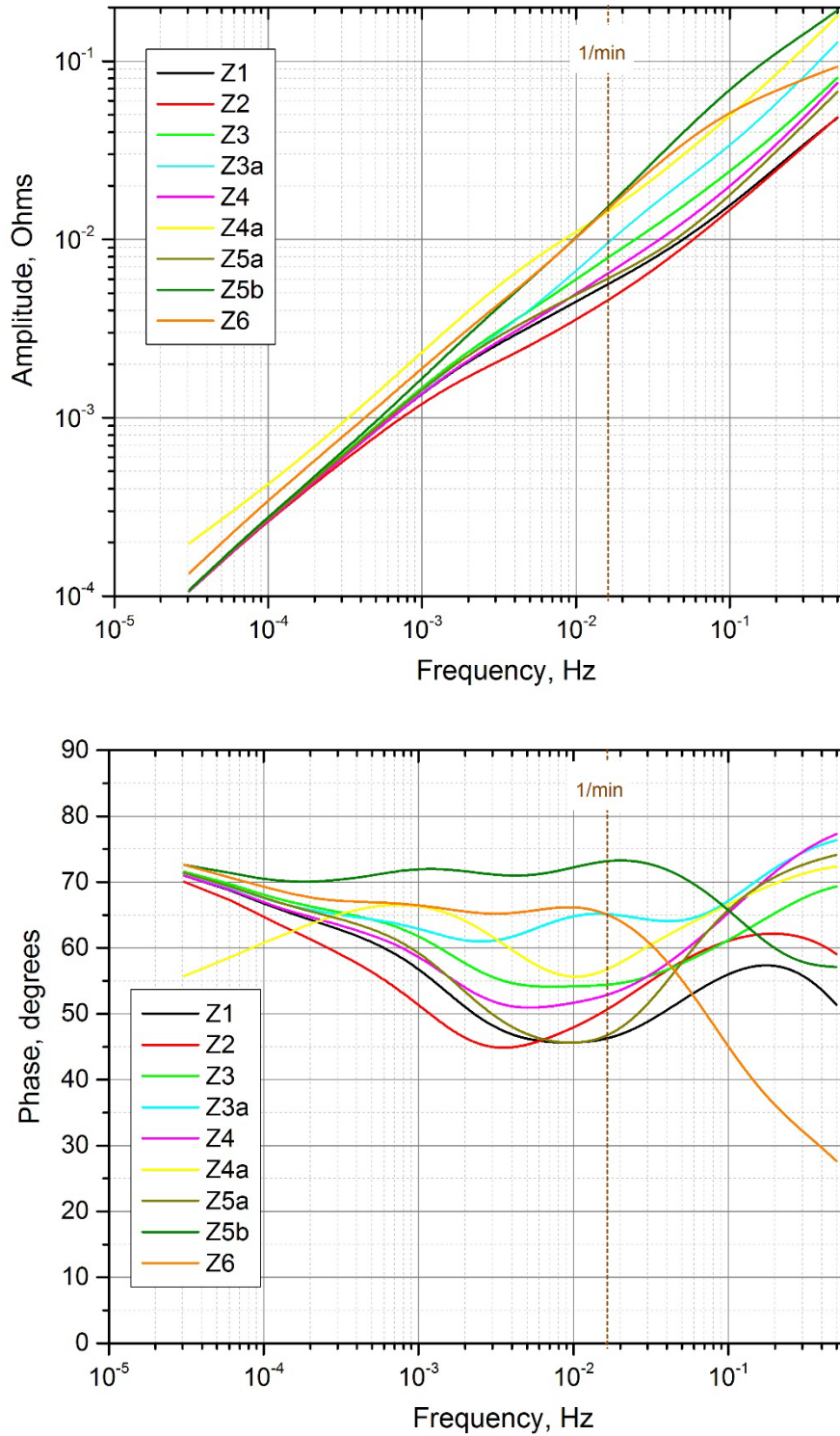


Figure 4.7.3. Surface impedance for 9 layered Earth models (top-amplitude, bottom- phase). Frequencies are corresponding to periods from 1 day to 1 second

4. 8. Prince Edward Island (PEI)

Map showing the areas of different Earth's resistivity models for Prince Edward Island is presented in Figure 4.8.1, Table 4.8.1 and Figure 4.8.2 summarize the resistivity models, and Figure 4.8.3 shows variations of surface impedance with frequency.

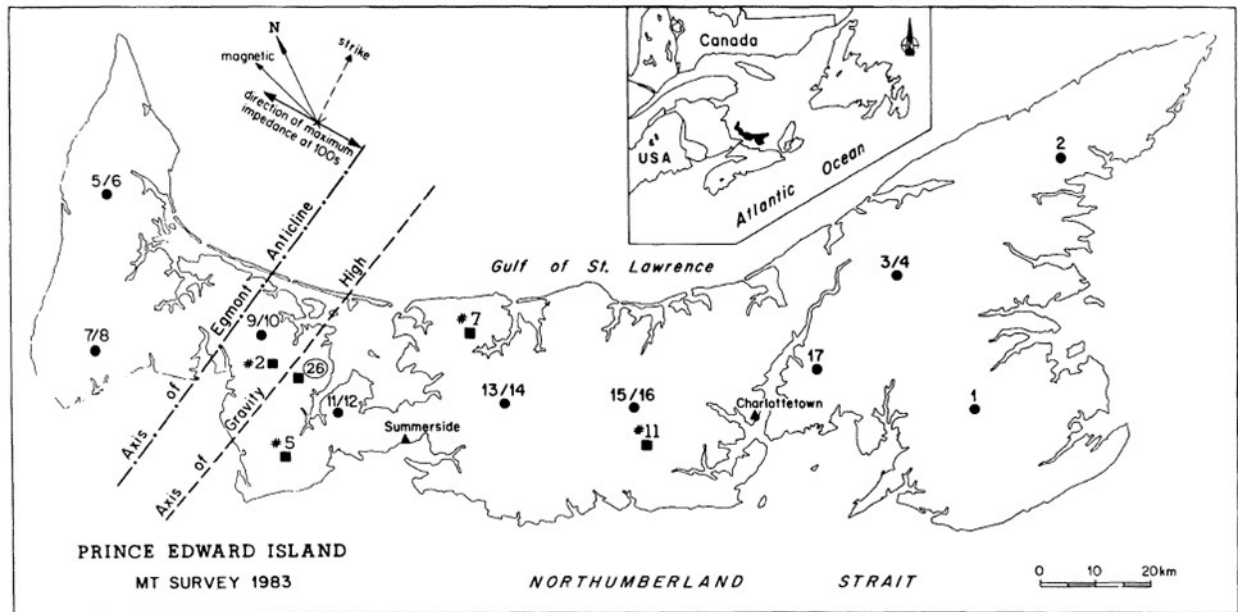


Figure 4.8.1. Map of PEI (only one layered Earth model was identified) with location of MT sounding sites (circles), squares indicate location of boreholes, [16]. See OF 8595, Appendix 8 for more details.

Table 4.8.1 Summary of 1D Earth Resistivity Model for PEI

Layer	Zone 1
1 – Overburden	2 m thick 25 ohm.m
2 – Sedimentary Basin	0-3 km 3 km thick 140 ohm.m
3 – Upper Crust	3-8.8 km 5.8 km thick 2700 ohm.m
4 – Middle Crust	8.8-23 km 14.2 km thick 1000 ohm.m
5 – Lower Crust	23-40.5 km 17.5 km thick 1000 ohm.m
6 – Upper Mantle	40.5-100 km 59.5 km thick 100 ohm.m
7 – Upper Mantle	100-250 km 150 km thick 158 ohm.m
8 – Upper Mantle	250-410 km 160 km thick 29 ohm.m
9 – Transition Zone	410-520 km 110 km thick 8 ohm.m
10 – Transition Zone	520-670 km 160 km thick 2.4 ohm.m
11 – Lower Mantle	670-900 km 230 km thick 1.12 ohm.m
12 – Lower Mantle	900-1000 km 100 km thick 0.47 ohm.m

Changes of resistivity with depth for layered Earth model of Prince Edward Island

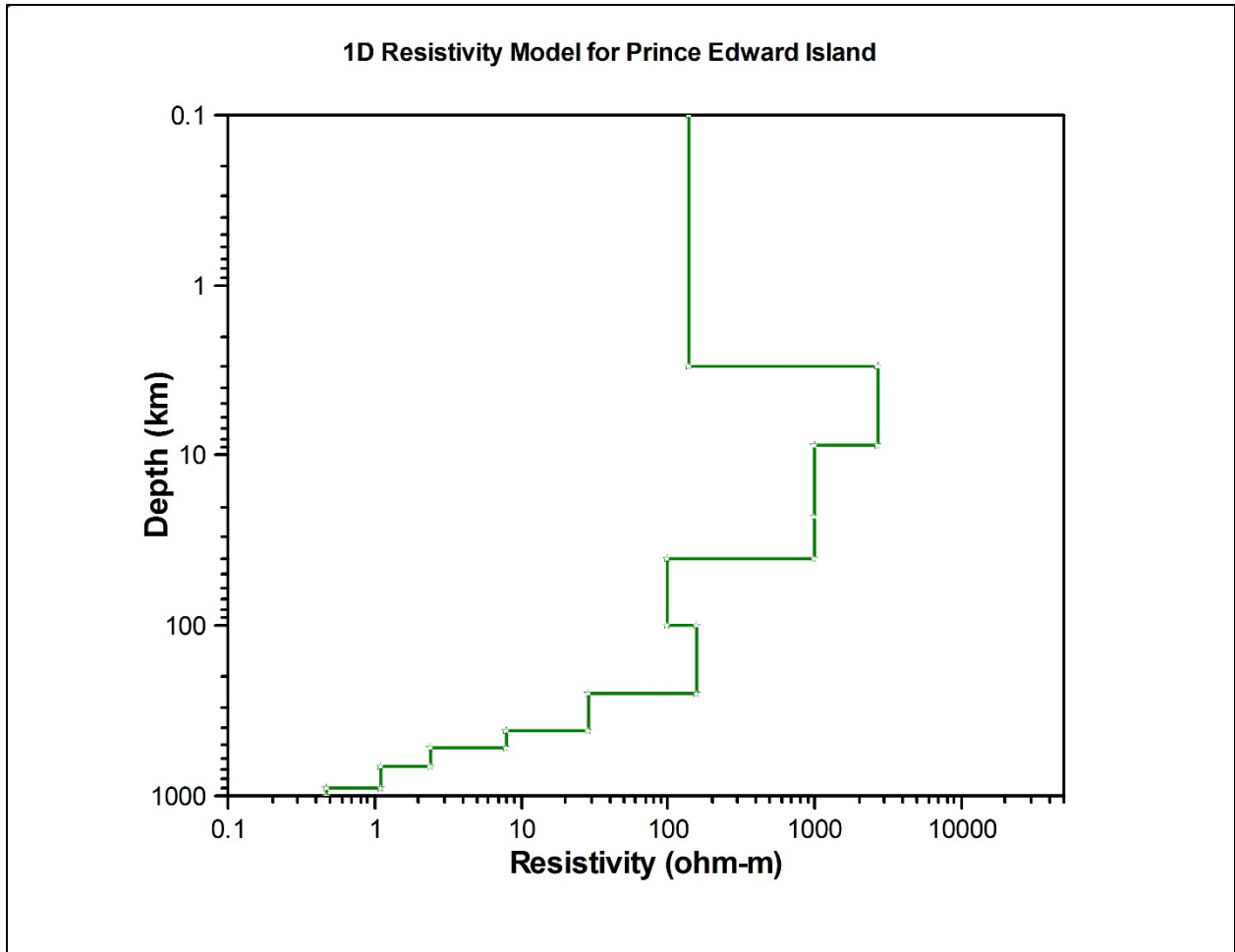


Figure 4.8.2. Variation of the resistivity for PEI. Vertical scale is depth in kilometers, horizontal scale is resistivity in Ohm·meter

Variations of surface impedance with frequency for PEI resistivity model

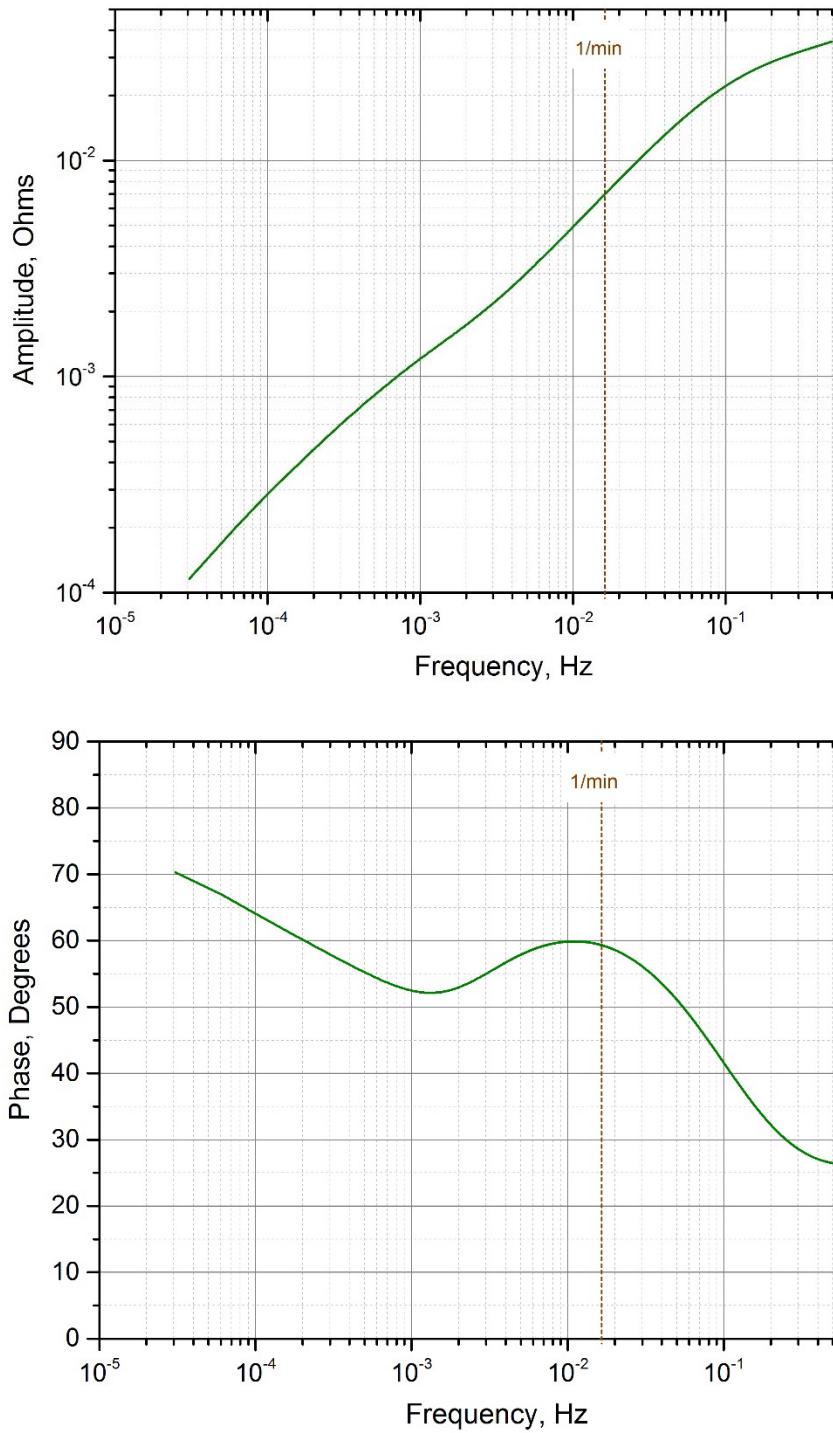


Figure 4.8.3. Variations of surface impedance (top-amplitude, bottom-phase) with frequency for PEI layered Earth model

4.9. Quebec

Map showing the areas of different Earth's resistivity models for Quebec is presented in Figure 4.9.1, Table 4.9.1 and Figure 4.9.2 summarize the resistivity models, and Figure 4.9.3 shows variations of surface impedance with frequency.

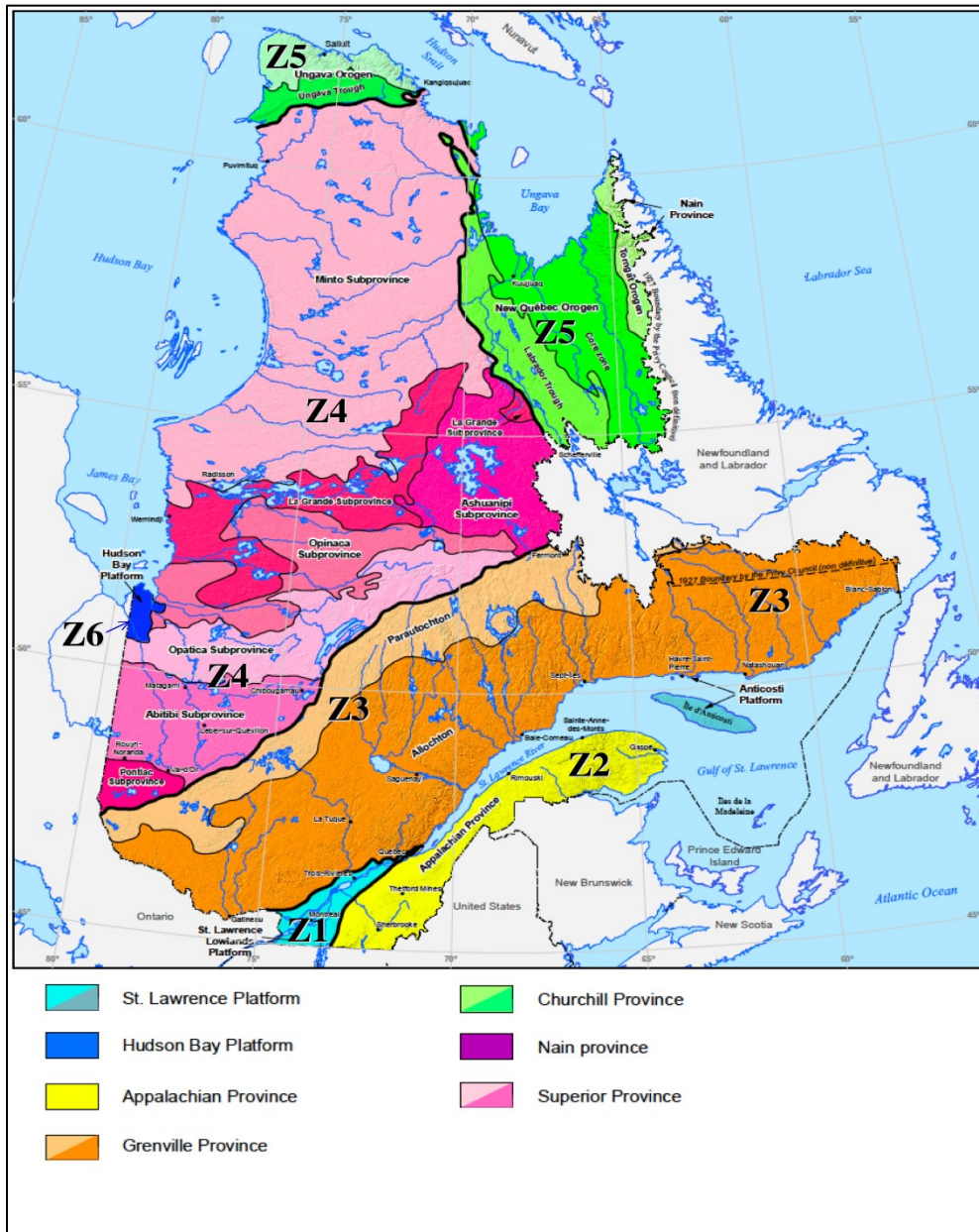


Figure 4.9.1. Identified Earth resistivity zones of Quebec mapped over Geological Provinces. See OF 8595, Appendix 9 for more details.

Table 4.9.1 Summary of 1D Earth Resistivity Models for Quebec (Zones 1 to 6)

Layer	Zone 1 (St. Lawrence Platform)	Zone 2 (Appalachian Province)	Zone 3 (Grenville Province)	Zone 4 (Superior Province)	Zone 5 (Churchill Province)	Zone 6 (Hudson Bay Platform)
1 – Overburd	30 m thick 20 ohm.m	2 - 105 m 25 ohm.m	1 m thick 80 ohm.m	5 m thick 80 ohm.m	2 m thick 80 ohm.m	25 m thick 30 ohm.m
2 – Sediment	2 km thick 200 ohm.m	absent	absent	absent	absent	0.25 km thick 100 ohm.m
3 – Upper Crust	2-10 km 8 km thick 4300 ohm.m	0-15 km 15 km thick 1500 ohm.m	0-13 km 13 km thick 20200 ohm.m	0-11 km 11 km thick 13700 ohm.m	0-6 km 6 km thick 10500 ohm.m	0.25-11 km 10.7 km thick 4900 ohm.m
4 – Middle Crust	10-30 km 20 km thick 300 ohm.m	15-22 km 7 km thick 3900 ohm.m	13-32 km 19 km thick 12700 ohm.m	11-28 km 17 km thick 1000 ohm.m	6-16 km 10 km thick 5000 ohm.m	11-31 km 20 km thick 280 ohm.m
5 – Lower Crust	30-45 km 15 km thick 300 ohm.m/	22-39 km 17 km thick 2200 ohm.m/	32-43 km 11 km thick 8600 ohm.m/	28-40 km 12 km thick 640 ohm.m/	16-38 km 22 km thick 1000 ohm.m/	31-38 km 7 km thick 2100 ohm.m/
6 – Upper Mantle	45-100 km 55 km thick 700 ohm.m/	39-100 km 61 km thick 3300 ohm.m/	43-100 km 57 km thick 2250 ohm.m/	40-100 km 60 km thick 125 ohm.m/	38-100 km 62 km thick 330 ohm.m/	38-100 km 62 km thick 550 ohm.m/
7 – Upper Mantle	100-250 km 150 km thick 300 ohm.m	100-250 km 150 km thick 3600 ohm.m	100-250 km 150 km thick 280 ohm.m	100-250 km 150 km thick 50 ohm.m	100-250 km 150 km thick 50 ohm.m	100-250 km 150 km thick 50 ohm.m
8 – Upper Mantle	250-410 km 160 km thick 29 ohm.m	250-410 km 160 km thick 150 ohm.m	250-410 km 160 km thick 50 ohm.m	250-410 km 160 km thick 29 ohm.m	250-410 km 160 km thick 29 ohm.m	250-410 km 160 km thick 14 ohm.m
9 – Transition Zone	410-520 km 110 km thick 8 ohm.m	410-520 km 110 km thick 8 ohm.m	410-520 km 110 km thick 8 ohm.m	410-520 km 110 km thick 8 ohm.m	410-520 km 110 km thick 8 ohm.m	410-520 km 110 km thick 8 ohm.m
10 – Transition Zone	520-670 150 km thick 2.4 ohm.m	520-670 150 km thick 2.4 ohm.m	520-670 150 km thick 2.4 ohm.m	520-670 150 km thick 2.4 ohm.m	520-670 150 km thick 2.4 ohm.m	520-670 150 km thick 2.4 ohm.m
11 – Lower Mantle	670-900 km 230 km thick 1.12 ohm.m	670-900 km 230 km thick 1.12 ohm.m	670-900 km 230 km thick 1.12 ohm.m	670-900 km 230 km thick 1.12 ohm.m	670-900 km 230 km thick 1.12 ohm.m	670-900 km 230 km thick 1.12 ohm.m
12 – Lower Mantle	900-1000 km 100 km thick 0.48 ohm.m	900-1000 km 100 km thick 0.48 ohm.m	900-1000 km 100 km thick 0.48 ohm.m	900-1000 km 100 km thick 0.48 ohm.m	900-1000 km 100 km thick 0.48 ohm.m	900-1000 km 100 km thick 0.48 ohm.m

Changes of resistivity with depth for 6 Zones of resistivity models for Quebec

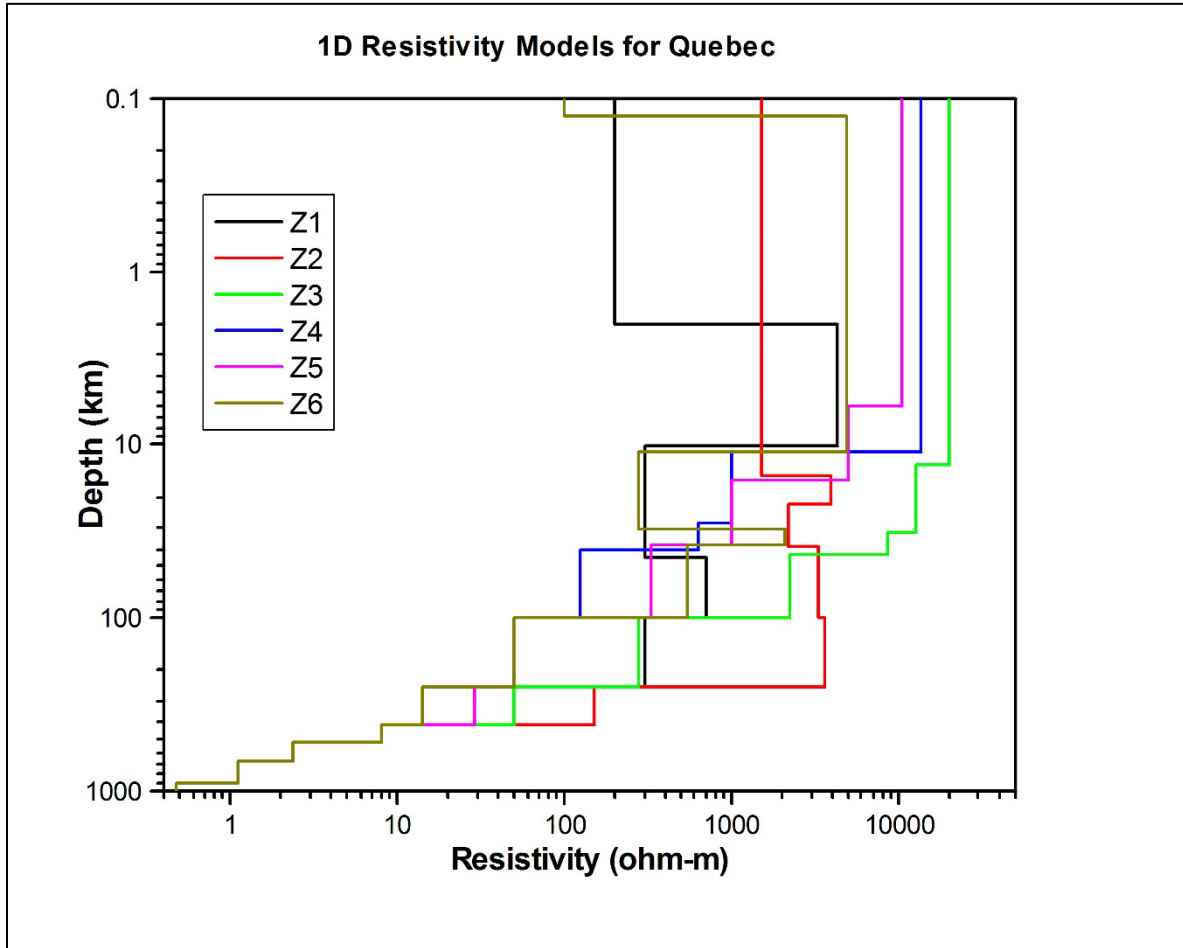


Figure 4.9.2. Variation of the resistivity for Quebec. Vertical scale is depth in kilometers, horizontal scale is resistivity in Ohm·meter

Variations of surface impedance with frequency for all Quebec resistivity models

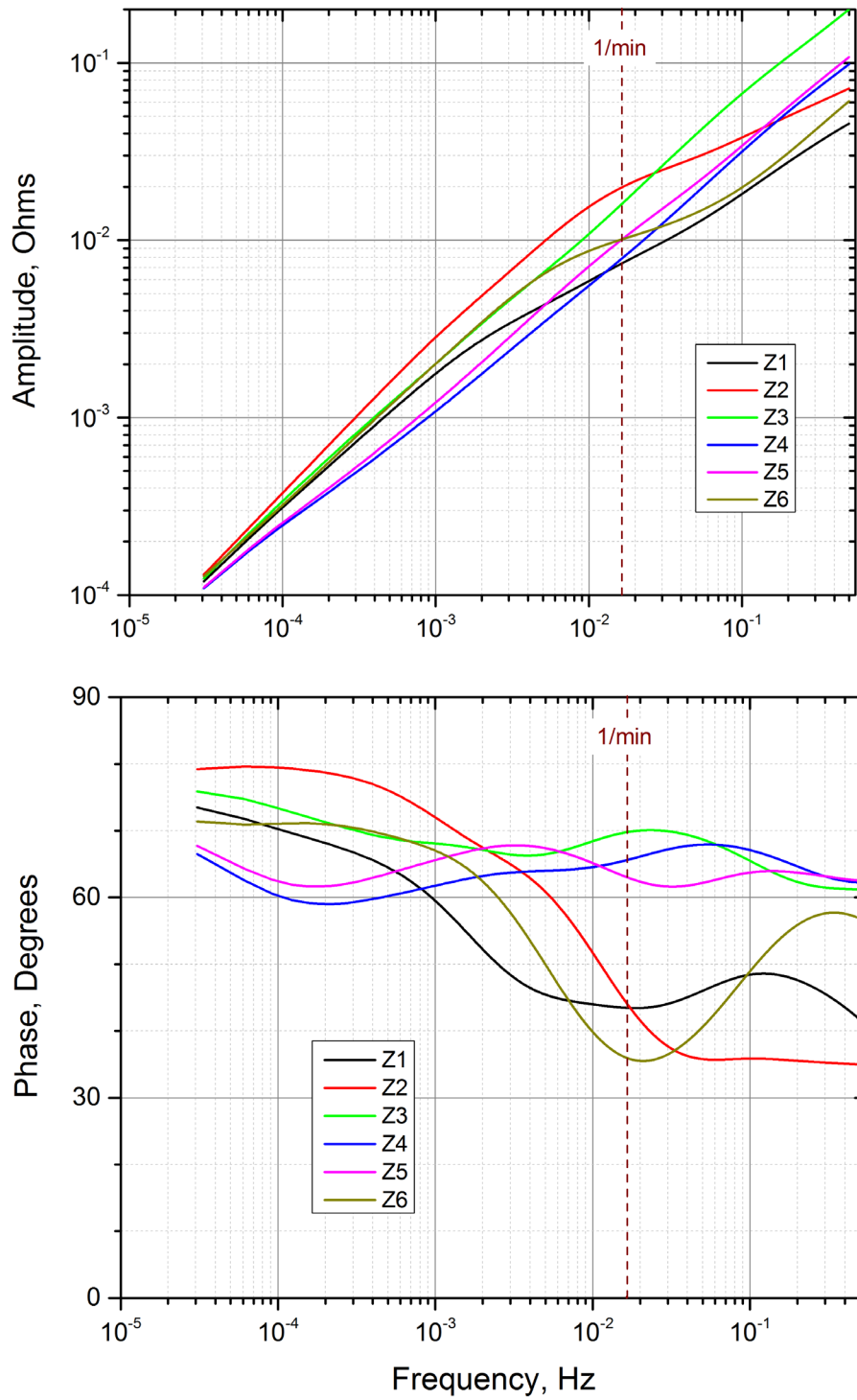


Figure 4.9.3. Surface impedance for Quebec layered Earth models (amplitude and phase). Frequencies are corresponding to periods from 1 day to 1 second

4.10. Saskatchewan

Map showing the areas of different Earth's resistivity models for Saskatchewan is presented in Figure 4.10.1, Table 4.10.1 and Figure 4.10.2 summarize the resistivity models, and Figure 4.10.3 shows variations of surface impedance with frequency.

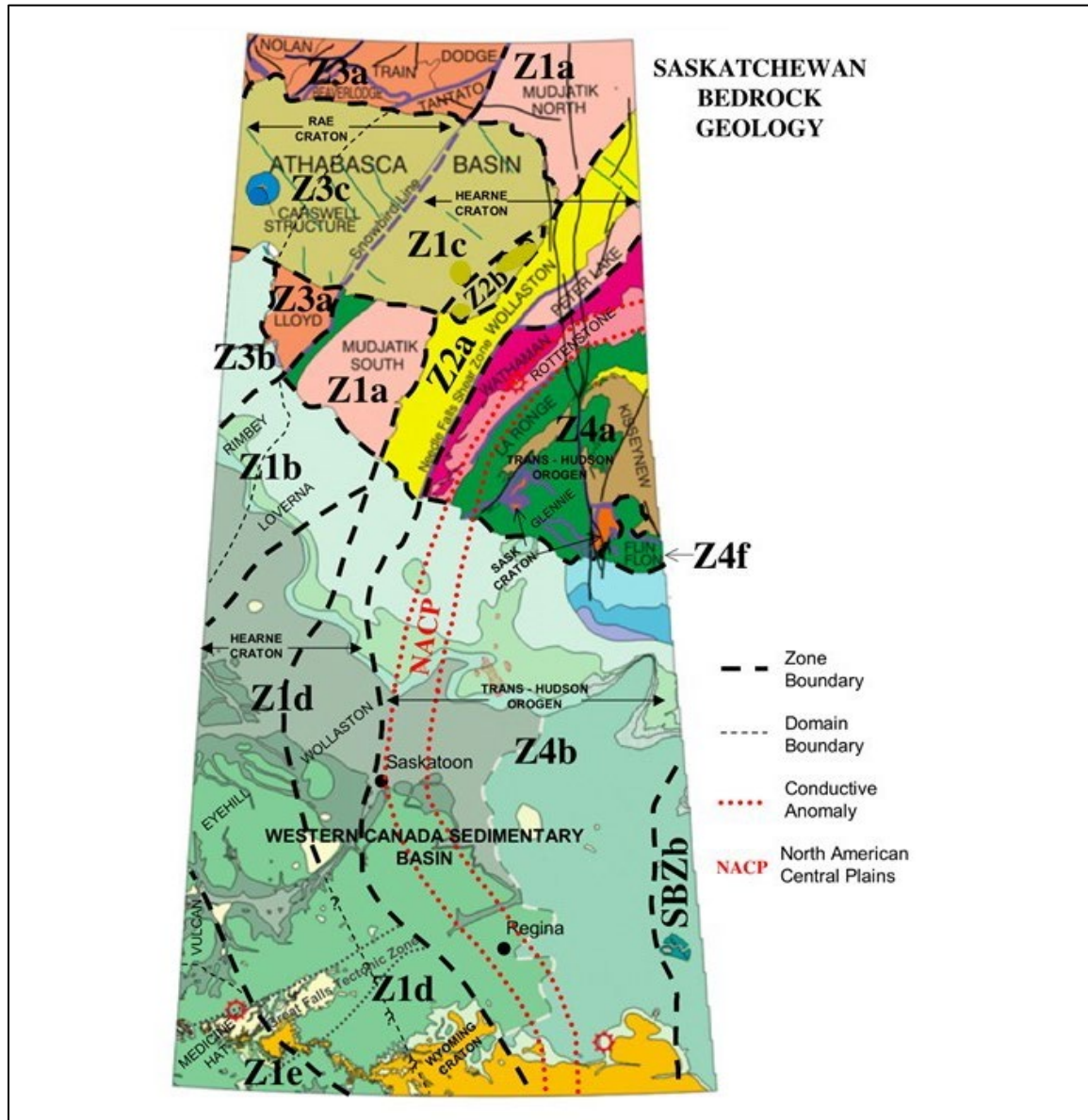


Figure 4.10.1. Areas of 1D resistivity models (Zones 1a-4f+Zone SBZb) are outlines (black dashed line) on top of the Geological map. The underlined map represents the geological Provinces, lithotectonic domains and major tectonic elements within Saskatchewan (after [17]). See OF 8595, Appendix 10 for more details.

Table 4.10.1 1D Earth Resistivity Models for Saskatchewan (Zones 1a-1e)

Layer	Zone 1a	Zone 1b	Zone 1c	Zone 1d	Zone 1e
1 – Overburden	3 m thick 100 ohm.m	100 m thick 25 ohm.m	15 m thick 100 ohm.m	100 m thick 25 ohm.m	50 m thick 25 ohm.m
2 – Sedimentary Basin	absent	0.1-1.8 km 1.7 km thick 10 ohm.m	0.1-1.55 km 1.45 km thick 2200 ohm.m	0.1-1.8 km 1.7 km thick 10 ohm.m	0-2.4 km 2.4 km thick 10 ohm.m
3 – Upper Crust	0-13.5 km 13.5 km thick 16900 ohm.m	1.8-16 km 14.2 km thick 2300 ohm.m	1.5-13.5 km 12 km thick 12800 ohm.m	1.8-16 km 14.2 km thick 2200 ohm.m	2.4-22 km 19.6 km thick 1700 ohm.m
4 – Middle Crust	13.5-27 km 13.5 km thick 4350 ohm.m	16-28 km 12 km thick 2500 ohm.m	13.5-27 km 13.5 km thick 4350 ohm.m	16-29 km 13 km thick 1950 ohm.m	22-35 km 13 km thick 3200 ohm.m
5 – Lower Crust	27-38 km 11 km thick 4350 ohm.m	28-37 km 9 km thick 2000 ohm.m	27-37.5 km 9.5 km thick 4350 ohm.m	29-42 km 13 km thick 900 ohm.m	35-46 km 11 km thick 4000 ohm.m
6 – Upper Mantle	38-100 km 62 km thick 500 ohm.m	37-100 km 63 km thick 1600 ohm.m	37-100 km 63 km thick 1600 ohm.m	42-100 km 58 km thick 550 ohm.m	46-100 km 54 km thick 4000 ohm.m
7 – Upper Mantle	100-250 km 150 km thick 200 ohm.m	100-250 km 150 km thick 180 ohm.m	100-250 km 150 km thick 180 ohm.m	100-250 km 150 km thick 350 ohm.m	100-250 km 150 km thick 425 ohm.m
8 – Upper Mantle	250-410 km 160 km thick 29 ohm.m	250-410 km 160 km thick 29 ohm.m	250-410 km 160 km thick 29 ohm.m	250-410 km 160 km thick 90 ohm.m	250-410 km 160 km thick 70 ohm.m
9 – Transition Zone	410-520 km 110 km thick 8 ohm.m	410-520 km 110 km thick 8 ohm.m	410-520 km 110 km thick 8 ohm.m	410-520 km 110 km thick 8 ohm.m	410-520 km 110 km thick 8 ohm.m
10 –Transition Zone	520-670 150 km thick 2.4 ohm.m	520-670 150 km thick 2.4 ohm.m	520-670 150 km thick 2.4 ohm.m	520-670 150 km thick 2.4 ohm.m	520-670 150 km thick 2.4 ohm.m
11 – Lower Mantle	670-900 km 230 km thick 1.12 ohm.m	670-900 km 230 km thick 1.12 ohm.m	670-900 km 230 km thick 1.12 ohm.m	670-900 km 230 km thick 1.12 ohm.m	670-900 km 230 km thick 1.12 ohm.m
12 – Lower Mantle	900-1000 km 100 km thick 0.48 ohm.m	900-1000 km 100 km thick 0.48 ohm.m	900-1000 km 100 km thick 0.48 ohm.m	900-1000 km 100 km thick 0.48 ohm.m	900-1000 km 100 km thick 0.48 ohm.m

Table 4.10.1 (continued) 1D Earth Resistivity Models for Saskatchewan (Zones 2a-3c)

Layer	Zone 2a	Zone 2b	Zone 3a	Zone 3b	Zone 3c
1 – Overburden	3 m thick 115 ohm.m	15 m thick 115 ohm.m	5 m thick 100 ohm.m	100 m thick 100 ohm.m	25 m thick 100 ohm.m
2 – Sedimentary Basin	absent	0-0.4 km 0.4 km thick 2200 ohm.m	absent	0.1-0.3 km 0.2 km thick 10 ohm.m	0-0.75 km 0.75 km thick 2200 ohm.m
3 – Upper Crust	0-13.5 km 13.5 km thick 2500 ohm.m	0.4-13.5 km 13.1 km thick 4600 ohm.m	0-18 km 18 km thick 37500 ohm.m	0.3-18 km 17.7 km thick 37500 ohm.m	0.75-18 km 17.25 km thick 37500 ohm.m
4 – Middle Crust	13.5-28 km 14.5 km thick 2300 ohm.m	13.5-28 km 14.5 km thick 2300 ohm.m			
5 – Lower Crust	28-38 km 10 km thick 900 ohm.m	28-38 km 10 km thick 900 ohm.m	18-36 km 18 km thick 11500 ohm.m	18-36 km 18 km thick 11500 ohm.m	18-36 km 18 km thick 11500 ohm.m
6 – Upper Mantle	38-100 km 62 km thick 600 ohm.m	38-100 km 62 km thick 600 ohm.m	36-100 km 64 km thick 23600 ohm.m	36-100 km 64 km thick 23600 ohm.m	36-100 km 64 km thick 23600 ohm.m
7 – Upper Mantle	100-250 km 150 km thick 200 ohm.m	100-250 km 150 km thick 200 ohm.m	100-250 km 150 km thick 24800 ohm.m	100-250 km 150 km thick 24800 ohm.m	100-250 km 150 km thick 24800 ohm.m
8 – Upper Mantle	250-410 km 160 km thick 29 ohm.m	250-410 km 160 km thick 29 ohm.m	250-410 km 160 km thick 500 ohm.m	250-410 km 160 km thick 500 ohm.m	250-410 km 160 km thick 500 ohm.m
9 – Transition Zone	410-520 km 110 km thick 8 ohm.m	410-520 km 110 km thick 8 ohm.m	410-520 km 110 km thick 8 ohm.m	410-520 km 110 km thick 8 ohm.m	410-520 km 110 km thick 8 ohm.m
10 – Transition Zone	520-670 150 km thick 2.4 ohm.m	520-670 150 km thick 2.4 ohm.m	520-670 150 km thick 2.4 ohm.m	520-670 150 km thick 2.4 ohm.m	520-670 150 km thick 2.4 ohm.m
11 – Lower Mantle	670-900 km 230 km thick 1.12 ohm.m	670-900 km 230 km thick 1.12 ohm.m	670-900 km 230 km thick 1.12 ohm.m	670-900 km 230 km thick 1.12 ohm.m	670-900 km 230 km thick 1.12 ohm.m
12 – Lower Mantle	900-1000 km 100 km thick 0.48 ohm.m	900-1000 km 100 km thick 0.48 ohm.m	900-1000 km 100 km thick 0.48 ohm.m	900-1000 km 100 km thick 0.48 ohm.m	900-1000 km 100 km thick 0.48 ohm.m

Table 4.10.1 (continued) 1D Earth Resistivity Models for Saskatchewan (Zones 4a-SBZb)

Layer	Zone 4a	Zone 4b	Zone 4f	Zone SBZb
1 – Overburden	2 m thick 100 ohm.m	100 m thick 25 ohm.m	1 m thick 70 ohm.m	75 m thick 25 ohm.m
2 – Sedimentary Basin	absent	0.1-1.5 km 1.4 km thick 5 ohm.m	absent	0-1.3 km 1.3 km thick 5 ohm.m
3 – Upper Crust	0-16 km 16 km thick 9200 ohm.m	1.5-12.5 km 11 km thick 350 ohm.m	0-14.5 km 14.5 km thick 1700 ohm.m	1.3-12.5 km 11.2 km thick 500 ohm.m
4 – Middle Crust	16-28 km 12 km thick 12500 ohm.m	12.5-39 km 26.5 km thick 375 ohm.m	14.5-23.5 km 9 km thick 1500 ohm.m	12.5-35 km 22.5 km thick 100 ohm.m
5 – Lower Crust	28-40 km 12 km thick 5800 ohm.m	39-46 km 7 km thick 300 ohm.m	23.5-44 km 20.5 km thick 1700 ohm.m	35-45 km 10 km thick 100 ohm.m
6 – Upper Mantle	40-100 km 60 km thick 450 ohm.m	46-100 km 54 km thick 500 ohm.m	44-100 km 56 km thick 500 ohm.m	45-100 km 55 km thick 80 ohm.m
7 – Upper Mantle	100-250 km 150 km thick 160 ohm.m	100-250 km 150 km thick 300 ohm.m	100-250 km 150 km thick 500 ohm.m	100-250 km 150 km thick 55 ohm.m
8 – Upper Mantle	250-410 km 160 km thick 29 ohm.m	250-410 km 160 km thick 29 ohm.m	250-410 km 160 km thick 29 ohm.m	250-410 km 160 km thick 29 ohm.m
9 – Transition Zone	410-520 km 110 km thick 8 ohm.m	410-520 km 110 km thick 8 ohm.m	410-520 km 110 km thick 8 ohm.m	410-520 km 110 km thick 8 ohm.m
10 – Transition Zone	520-670 150 km thick 2.4 ohm.m	520-670 150 km thick 2.4 ohm.m	520-670 150 km thick 2.4 ohm.m	520-670 150 km thick 2.4 ohm.m
11 – Lower Mantle	670-900 km 230 km thick 1.12 ohm.m	670-900 km 230 km thick 1.12 ohm.m	670-900 km 230 km thick 1.12 ohm.m	670-900 km 230 km thick 1.12 ohm.m
12 – Lower Mantle	900-1000 km 100 km thick 0.48 ohm.m	900-1000 km 100 km thick 0.48 ohm.m	900-1000 km 100 km thick 0.48 ohm.m	900-1000 km 100 km thick 0.48 ohm.m

Changes of resistivity with depth for layered Earth models of Saskatchewan

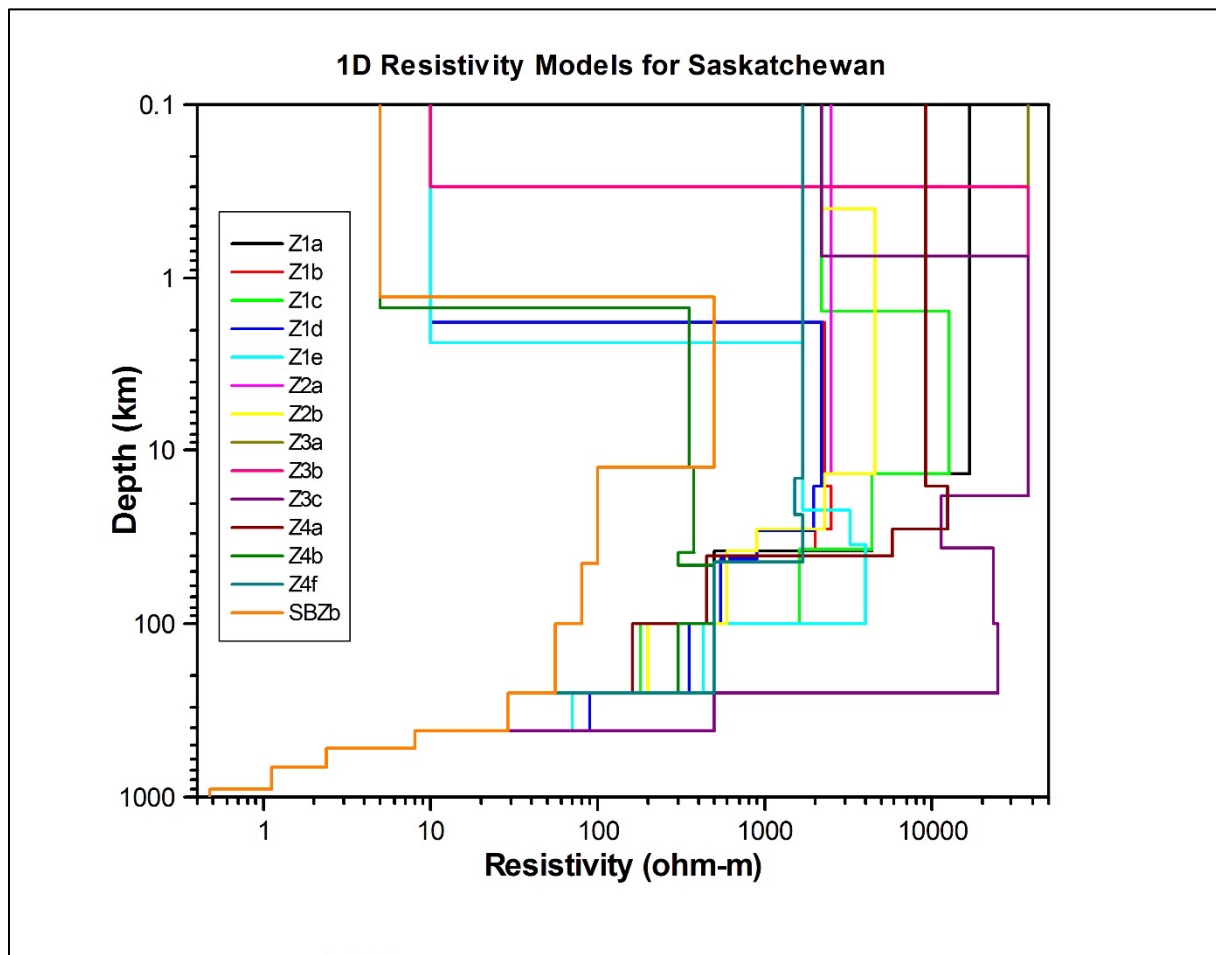


Figure 4.10.2. Variations of the resistivity with depth for 14 identified Zones of Saskatchewan. Vertical scale is depth in kilometers, horizontal scale is resistivity in Ohm-meter

Variations of surface impedance with frequency for 14 Saskatchewan resistivity models

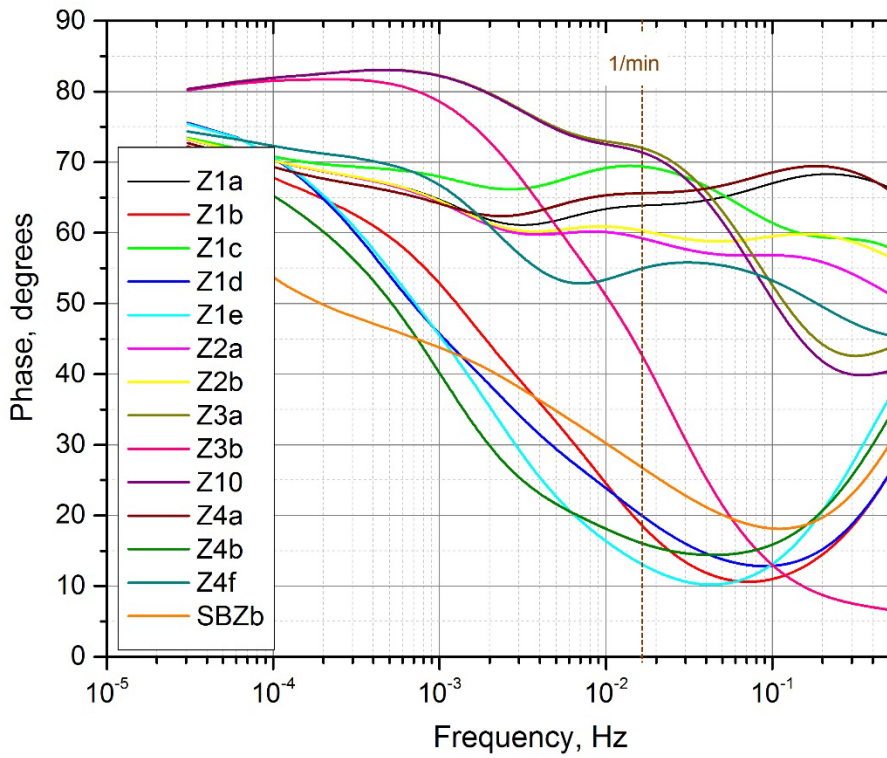
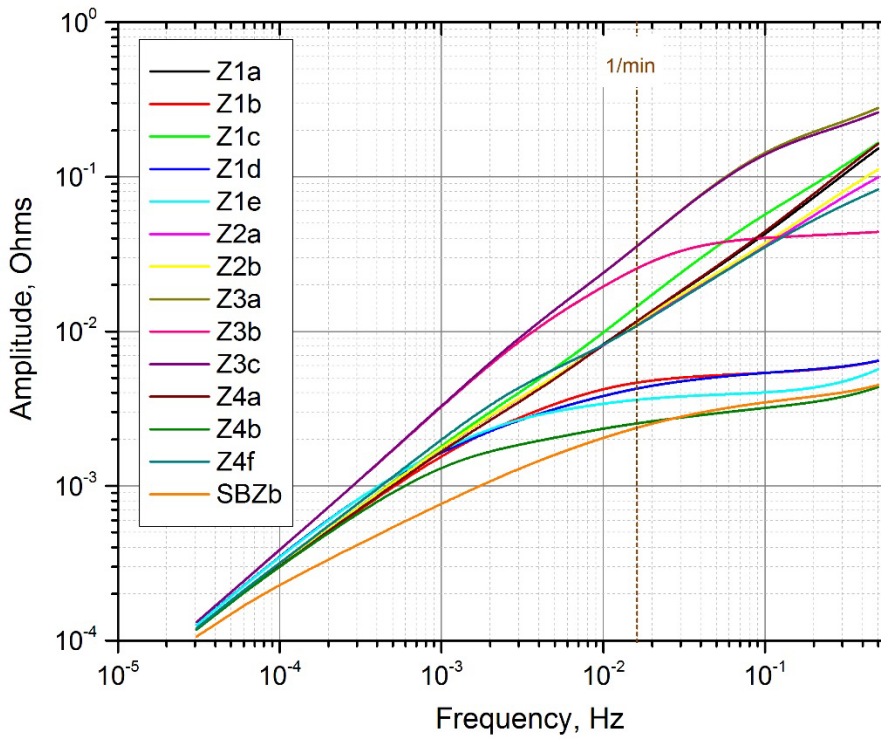


Figure 4.10.3. Variations of surface impedances (top-amplitude, bottom-phase) with frequency for 14 layered Earth models

5. Conclusions

This report contains the summary information for the multiple one-dimensional Earth resistivity models identified for each of 10 provinces of Canada. For some provinces, as many as 14 different zones were identified (Manitoba), while there is only one zone for the smallest province (PEI).

For GIC studies, the plots of the surface impedance variations with frequency were presented. For each province, it is easy to identify the Zone with the highest amplitude (where the geoelectric field will be the largest) and the lowest (with geoelectric field lower) as well as the midpoint.

Thus, for some studies there might be no need to model geoelectric field for all 14 Zones, while for others (comparative studies, for example), the detailed layered Earth models would be useful.

As well, based on the presented plots, the anomalous behavior of the impedance can be inferred together with the expansion of the area of this anomalous behavior. From this, the conclusion might be drawn to exclude this area from the study, if the area is small in comparison with the overall spread of the power network system. Such as, for example, Zone 4a of Ontario, Superior Kapuskasing Uplift, which is relatively small, as presented in Figure 4.7.1.

Detailed information with all references can be found in the complementary OF 8595, <https://doi.org/10.4095/314805>, where the models, established for each province, are detailed and described in separate Appendices, thus providing all the essential information for justification and for possible further updates if more detailed MT survey results will become available in the future.

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