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Regional Surface Electrical Conductance Map of India

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Abstract: Electrical conductance is one of the important parameters in the interpretation of electrical and electromagnetic data. Study of the distribution of conductance parameter in a region helps to understand the subsurface geoelectric structure. Based on the results obtained from shallow electrical resistivity soundings, deep resistivity and magnetotelluric (MT) soundings, geological sections derived from a few deep seismic soundings (DSS) and from shallow and deep boreholes, an attempt has been made here to construct a regional electrical conductance map of India. Since the data is widely distributed more emphasis is given for the data from sedimentary basins. The map thus prepared gives the distribution of conductance values of various geological regions. The regions in Arunachal Pradesh, Assam in northeast, Ganga valley in the north and Cambay in western part show comparatively high conductance values, of the order of 400-1500 Siemens.

Keywords: Electrical conductance map, Regional model, Electrical basement, India.

INTRODUCTION

Global models are important to understand large variations of the Earth's processes. There has been considerable interest in recent years on global temperature variations (Mann et al. 1998; Parker, 2000), earth-ocean interaction studies (Caldeira and Duffy, 2000), global climate changes (Kerr, 1998; Dwyer, 2000) etc. Construction of a global model crucially depends on the regional databases. Among the various geophysical parameters studied on a global scale, electrical conductance is one of the important parameters that helps to understand the Earth's natural resources. Knowledge on the distribution of conductance at various depth levels and also its lateral variations pave the way for better understanding of the presence of water, mineral and hydrocarbon potential of a given region.

Water in oceans, water bearing rocks in sedimentary basins as well as weathered igneous and metamorphic rocks on land have high conductivity. The thickness of surface conductive layer on land varies from a few metres to a few kilometres. Large thickness of surface layer acts as a mask and interferes with our capability to understand the deep electrical structure (Keller, 1987). Beneath this layer lies a resistive rock extending to great depths, of t he order of 10 to 15 km, followed by conductive lower crust and mantle (Bailey, 1994). The electrical properties of the deep structure of the Earth are being investigated using various electromagnetic geophysical techniques such as magnetotellurics (Orange, 1989), geomagnetic deep sounding (Berdechevisky et al. 1976), and also deep resistivity sounding (Yungul, 1996). These methods respond strongly to the conductive surface layer. With the geometrical configuration and conductivity of the surface layer, the regional electrical conductance parameter – the product of conductivity and its thickness – can be computed. Knowledge on the electrical properties of surface layer helps to model the data more effectively (Keller, 1987).

Attempts have been made in different parts of the world for the preparation of conductance map both on a regional scale (Keller, 1987) and also on a global scale considering a spherical earth (Fainberg et al. 1983). In countries like the United States of America (USA) the information on the surface layer is well documented and available (Keller, 1987). Several oil companies are involved in drilling various sedimentary basins for hydrocarbon exploration studies. For example, in USA alone, 80,000 - 100,000 wells are being drilled each year with measurements of conductivity parameter of the rock at different depths being made in almost all cases. Until recently it was almost impracticable to compile the data and prepare a regional model of conductance map for a vast country like India because of the non-availability of data and also lack of data coverage over all the regions. The data made available from different organizations facilitates the estimation of conductance parameter.

METHODOLOGY

In an attempt to prepare a conductance map of India, data are considered from 103 MT and 270 deep resistivity soundings (DRS), 131 borehole lithologs, 366 shallow electrical resistivity soundings, 349 selected locations on the seismic sections and regional geotraverse covering various types of rocks (Fig.1). Information on resistivity, thickness and rock type for different layers is available in literature. Resistivities of the rock types are considered from various reports of GSI, NGRI etc. and also from research papers, for example, Kailasam et al. 1976; Singh et al. 1983; Sarma et al. 1994; Venkata Rao et al. 1995 etc. and these are summarized in Table 1. These values are based on the results of resistivity and MT surveys conducted in various parts of the country. As can be seen from Fig. 1, the density of the data is more over the sedimentary basins as compared to exposed basement terrains. In Fig.2, a few examples of subsurface sections considered in our study are shown. The rock formations above basement in Cuddapah basin (Nagaraja Rao et al. 1987) are shown in Figs.2a, b and Figs. 2c, d are taken from Bengal basin (Reddy et al. 1997), Fig.2 e-g are from Deccan syneclise (Kailasam, 1976), Narmada Son Lineament region (Venkata Rao et al. 1995) and Ganga basin (Singh et al. 1992) respectively. Such sections are derived for all the 1219 data locations.

In the database, the entire sequence of conductive

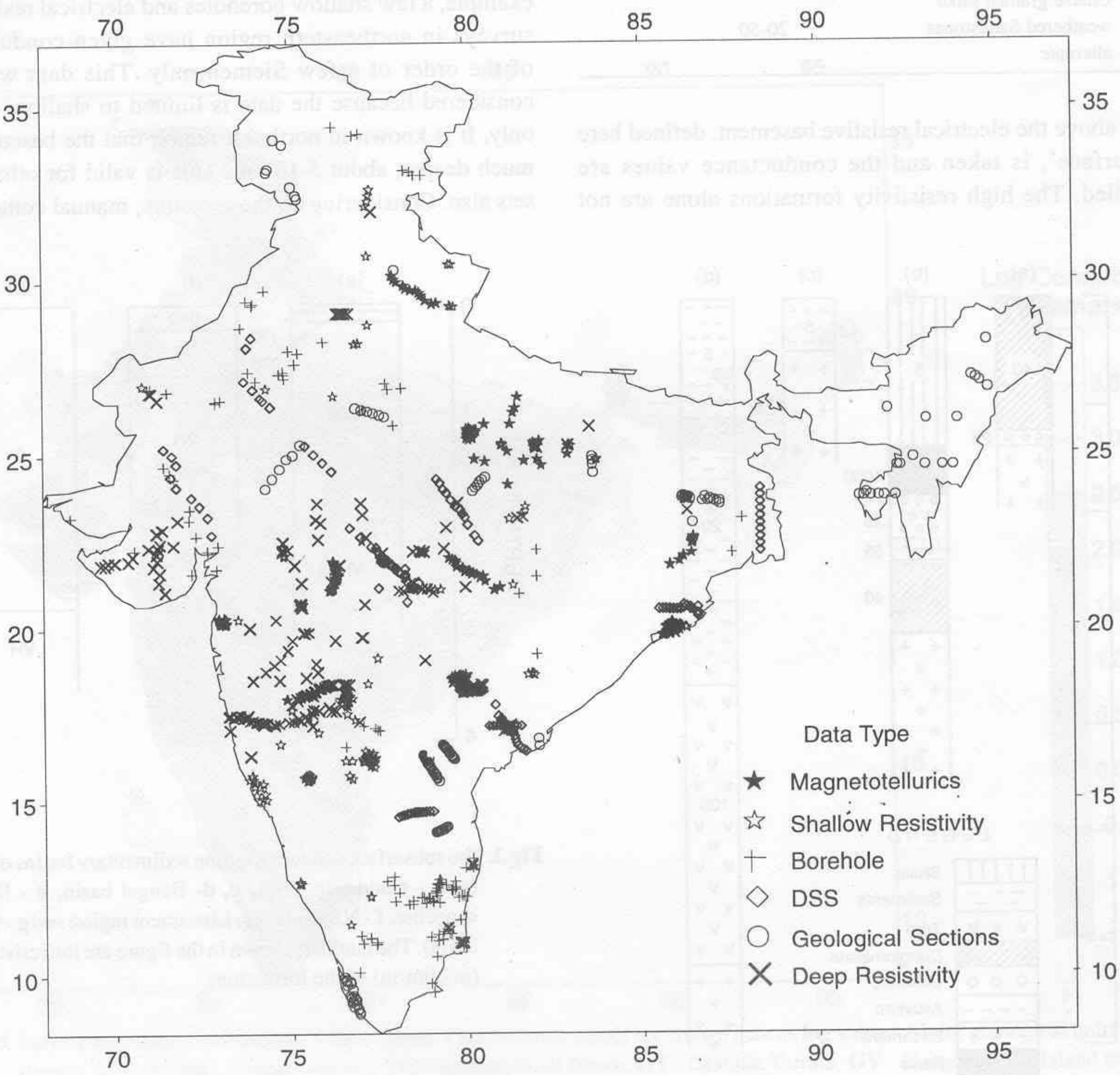

Fig.1. Location map of the database.

Table 1. Resistivity ranges in different rock types

Rock type	Resistivity Range (ohm-m)
Deccan Traps	30-225
Gondwana sediments	20-200
Alluvium	1-15
Vindhyan sediments	200-500
Mahakosala Phyllites	100-175
Kaimur Sandstones	400-900
Panna Shales	10-30
Quartzite	400-900
Limestones	40-700
Mahakosala Calc.schist	100-200
Sandstone (Kamthis)	3-15
Sandstone (Barakars)	30-90
Sandstone (Talchirs)	10-25
Laterite	50
Clays and Shale	1-12
Sand with Clay	10-20
Coarse grained sand/ weathered Sandstones alternate	20-50

rocks above the electrical resistive basement, defined here as 'surface', is taken and the conductance values are compiled. The high resistivity formations alone are not considered as electrical resistive basement(s). Other information such as regional geology, thickness and depth to high resistivity formation is also considered. At places of exposed basement, the weathered surface rock is of the order of a few metres. The assumption is consistent with the results of many electrical resistivity surveys (e.g., Ballukraya, 2001). The data from exposed basement regions of India, for example, some parts of eastern, northeastern and southern parts are not essential in the present study. At overlapping locations of data, emphasis is given in the following order- MT, deep resistivity, shallow resistivity, boreholes followed by data derived from geological sections from seismic studies and regional geotraverses. Also, we have not considered some data, which has given wild estimates of conductance values and is not in agreement with the known geology. For example, a few shallow boreholes and electrical resistivity surveys in northeastern region have given conductance of the order of a few Siemen only. This data was not considered because the data is limited to shallow depths only. It is known in northeast region that the basement is much deeper, about 5-10 km. This is valid for other data sets also. Considering all these factors, manual contouring

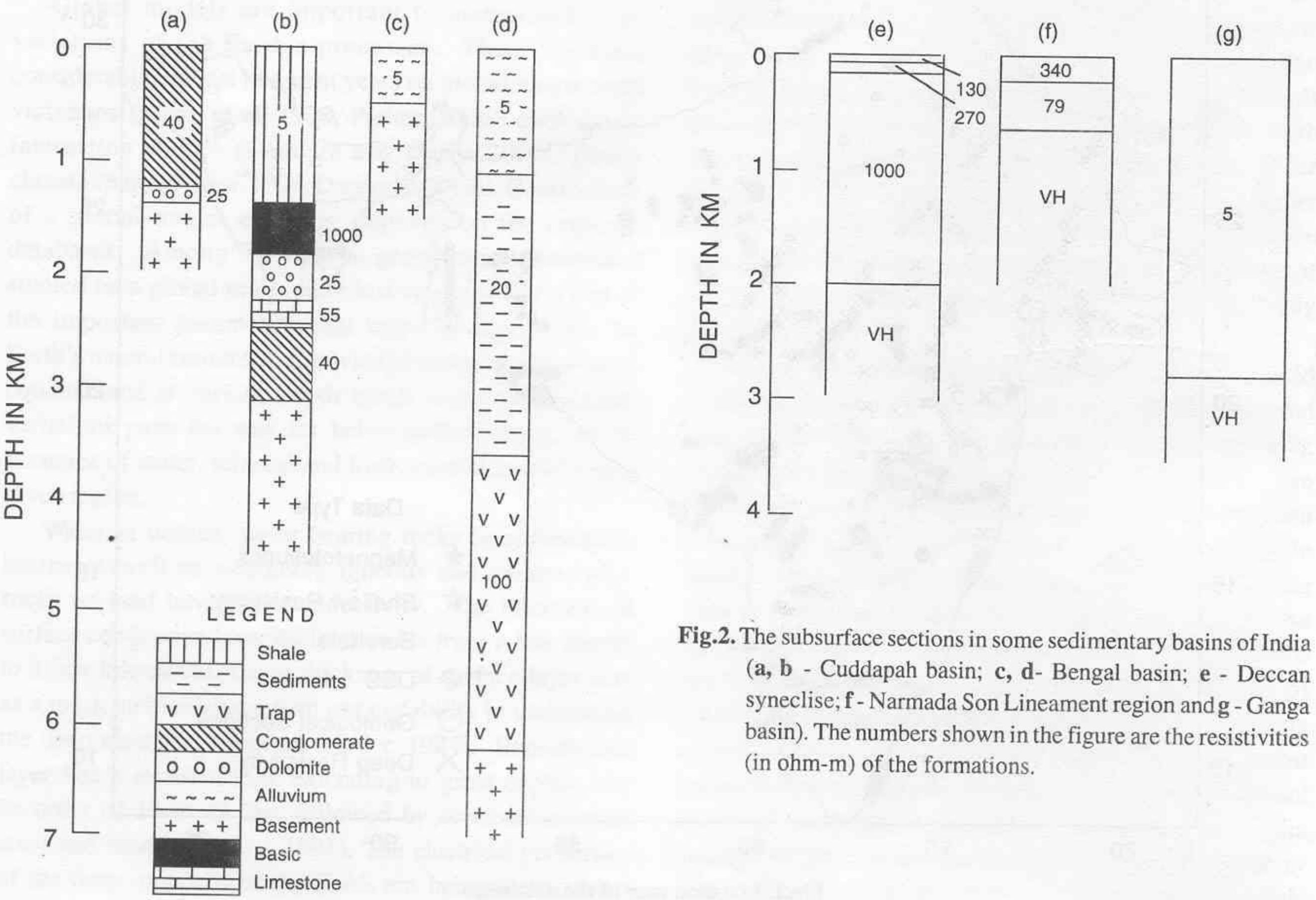

Fig.2. The subsurface sections in some sedimentary basins of India (**a, b** - Cuddapah basin; **c, d**- Bengal basin; **e** - Deccan syneclise; **f** - Narmada Son Lineament region and **g** - Ganga basin). The numbers shown in the figure are the resistivities (in ohm-m) of the formations.

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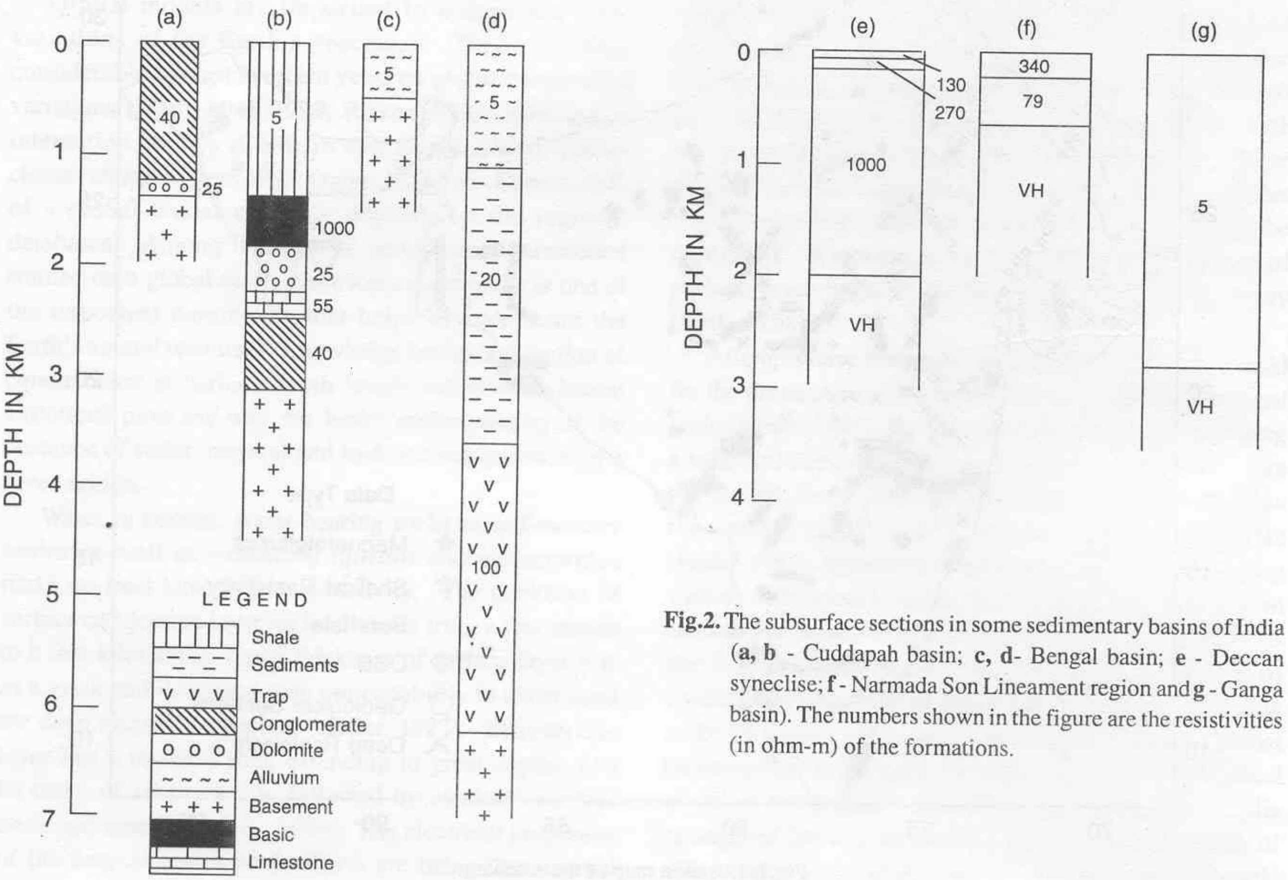

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of data (conductance values) are carried out before using computer aided tools and the contours are constrained to follow the geological boundaries.

RESULTS

The conductance map thus obtained is shown in Fig.3. The conductance values showed a large variation from 0.1 S over granitic and gneissic rocks to around 1500 S over thick sedimentary rocks. In view of this, log conductance values are shown for better approximation. A striking correlation, in the sense of magnitude, i.e., high conductance values with the known sedimentary basins of India (Bhandari, 1983) is evident. Deccan flood basalt (DB) region has 1-10 S and it is distinct from the high resistive granitic terrain (GT) towards the south. The Ganga valley (GV), along the Himalayan foot hills showed conductance, of the order of 200-500 S and Assam-Arakan (AA) fold belt region showed values, of the order of 1000-1500 S due to large thickness (5-8 km) of conductive formations. The source rock formation in the generation of hydrocarbons is highly conductive. While various geological and geochemical parameters are considered for the estimation of hydrocarbon potential (Miller, 1983; White and Gehman, 1979), the electrical conductance of a region can be an additional indicator.

SUMMARY AND CONCLUSIONS

An attempt has been made in the present study to compile the available geophysical data from the published literature in order to prepare a surface electrical conductance

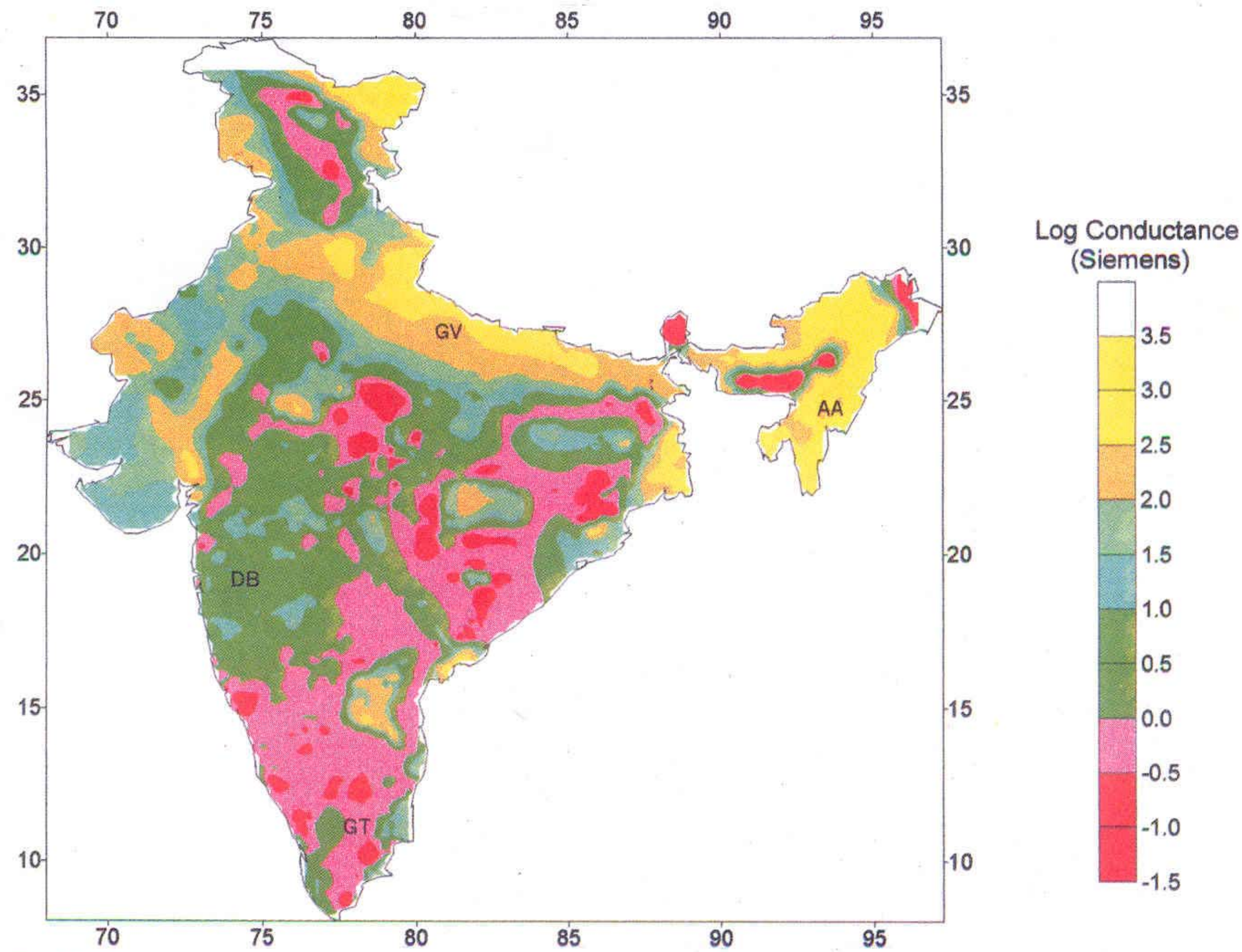

Fig. 3. Surface Electrical Conductance Map of India. Conductance values are shown here as log values. Major geological units are also shown: **AA** - Assam - Arakan fold belt, **DB** - Deccan flood Basalt, **GT** - Granitic Terrain, **GV** - Ganga Valley (Island territories of India not shown).

map of India on a regional scale. Similar attempts on a regional scale have been attempted for United States of America (Keller, 1987) and on a Global scale (Fainberg et al. 1983). No claim is made in our present study that the proposed map is complete in all respects. The available information will be continuously updated in order to get a refined electrical conductance map. However, our study is a beginning towards that direction. Most important results from our study are anomalous conductance values for the known geological provinces, for example, the major geological features like Assam-Arakan fold belt, Deccan flood basalt, Ganga valley, Cambay and Godavari basins are distinctly different from the neighbouring regions. Interestingly, the well known hydrocarbon potential regions such as Assam - Arakan fold belt and Cambay regions have shown anomalously high conductance values when compared to other regions.

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