"Physics of Auroral Phenomena", Proc. XXVII Annual Seminar, Apatity, pp. 17-20 , 2004

Polar Geophysical Institute

THE INFLUENCE OF LITHOSPHERIC DEEP FAULTS ON THE GROUND BASED GEOMAGNETIC FIELD MEASUREMENTS

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Abstract. We have found that some largest deep faults of the lithosphere are manifested in the horizontal component of the Earth's magnetic field. We have compiled a databank of magnetic stations located outside the lithospheric deep faults using the geological data. Every two chosen magnetic stations must be located nearly on the same corrected geomagnetic latitude, but above different tectonic zones. One of them should be located above the lithospheric deep fault and the other - outside a zone of deep faults. The horizontal geomagnetic field components measured at these stations were compared with each other. It has been shown that horizontal geomagnetic field component at the magnetic station, located above the lithospheric deep fault is much larger, than the value measured at the station located outside the deep fault's zone. The analysis of the horizontal geomagnetic field components measured at a large number of the magnetic stations located over different tectonic regions has shown that the above mentioned characteristic is quite persistent.

1. Introduction

It is well known that lithospheric irregularities affect the components of the Earth's magnetic field [*Logachev and Zaharov*, 1979]. We found that there are particular variations in the satellite measurements of the magnetic and electrical components of the low-frequency emissions, which are caused by Earth's crust structures [*Migulin et al*., 2000; *Migulin et al*., 2001]. Later we established that some large lithospheric deep faults manifest themselves in the horizontal component of the Earth's magnetic field.

In this paper the horizontal geomagnetic field components are analysed, which are registered by the ground based magnetic (magnetovariation) stations located above the deep faults and above high fissuring zones on the Earth's surface as well as within the Earth's crust.

2. Analysis experimental data

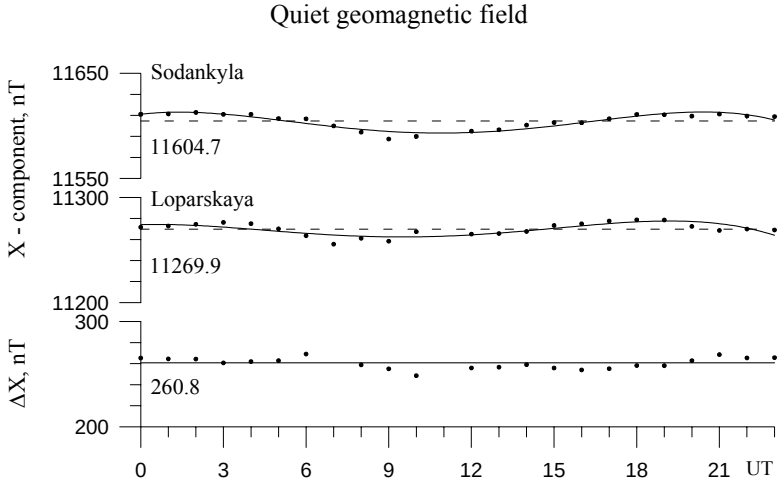
We have built a databank based on geological mapping in order to find deep faults and the high fissuring zones. The magnetic stations used were only those located outside the lithospheric deep faults. Every two chosen magnetic stations must be located nearly on the same corrected geomagnetic latitude but over different tectonic zones. One of them should be located above the node of crossing of lithosphere the deep faults (or the deep faults zones) and the other-outside the zones of deep faults. Measured horizontal geomagnetic field components at these stations were compared with each other. It has turned out that the horizontal geomagnetic field component at the magnetic station located above the deep fault is much larger than the value measured at the station located outside the deep fault. The magnitude difference depends from the geodynamic activity deep fault considered [*Larkina et al*., 2000].

Here we consider the results of the measurements of the horizontal H-component (or X–north component) of the quiet geomagnetic field [*Yanovskiy*, 1978] for the March 1991 and for the April 1996 at two magnetic stations: Sodankyla and Loparskaya. The corrected geomagnetic coordinates of these stations are 63.8°, 108.0° and 64.0°, 114.8° respectively [*Hakura*, 1965]. The Loparskaya station is located above a tectonically quiet area within the limits of the Norway–Kola massif. The Sodankyla station is located above the large fault of the northwest direction stretch, limiting the Lapland crystalline massif from the north.

The quiet geomagnetic field at these stations was calculated by five quiet days. For this, there were used the mean-hourly values of H-components at the Loparskaya station and X-north components at the Sodankyla station [*Ionospheric and Geomagnetic data*, 1991; *Geomagnetic, Ionospheric and Auroral data*, 1996]. Then, H-component at the Loparskaya station was recalculated into X-component and the values of the quiet geomagnetic field were compared between each other (Figire 1a). In this Figure the difference between ΔX-components of the geomagnetic field taking into account the latitude correction of 0.2° is shown too. The latitude correction was calculated using the IGRF model (International Geomagnetic Reference Field) [*Gustafsson et al*., 1992]. One has to take into consideration these corrections when calculating the geomagnetic field for the magnetic stations, located at different corrected geomagnetic latitudes. From Figure 1 one can see that the northern component of geomagnetic field at the Sodankyla station, located above the node of crossing faults is larger by 261 nT than at the Loparskaya located

outside the fault. The similar calculations were performed for the disturbed geomagnetic field and the results are shown in Figure 1b. The northern X-component of the disturbed geomagnetic field at the Sodankyla station is larger than at the Loparskaya station too and it is of the same order (260 nT). The magnitudes of difference for quiet and disturbed geomagnetic field for the April 1996 are 280 nT and 288 nT respectively.

a)



b)

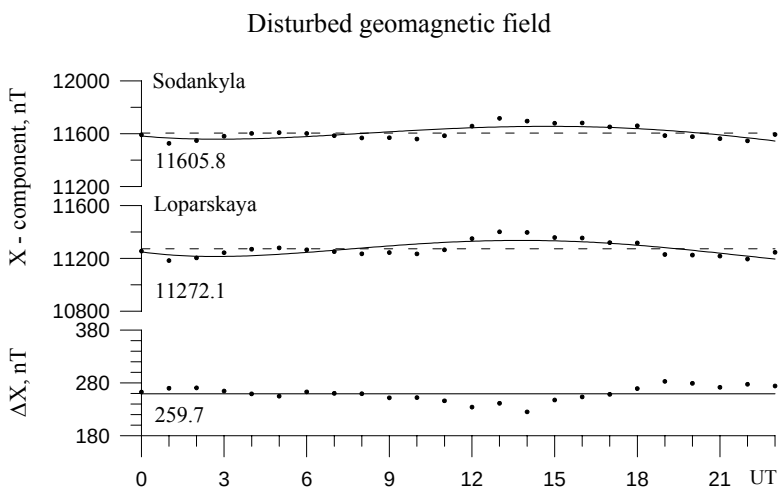


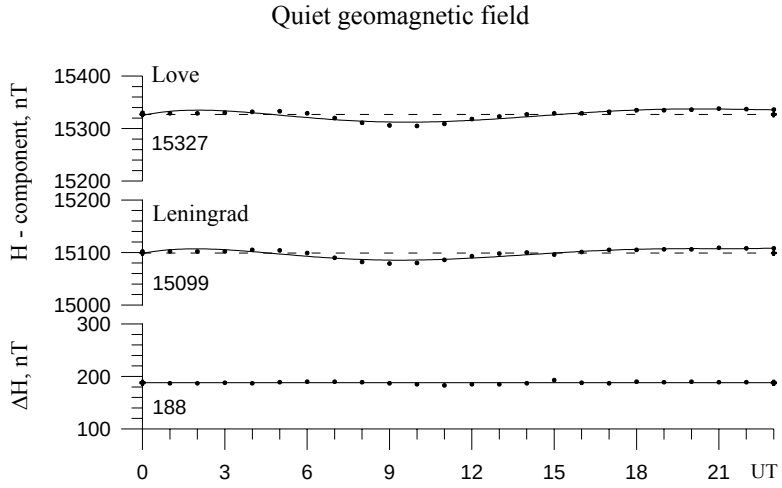
Figure 1. Daily variations of the mean hourly values of the northern geomagnetic field components (X) at the Sodankyla and Loparskaya stations, and the difference (ΔX) between them for the March 1991.

One has to note that northern X-component of the disturbed geomagnetic field includes a small Sq (solar-day) variation, the same as X-component of the quiet geomagnetic field but of somewhat lager amplitude. The solar-day Sq variation is a variety of the transitory modifications of the geomagnetic field, which are connected with the solar activity and with the upper atmospheric processes.

Figure 2 presents the observed values of the horizontal H-component of the quiet and disturbed geomagnetic field for the March 1964 at two stations: the Leningrad and Love ones. The corrected geomagnetic coordinates of these stations are 55.7°, 108.1° and 55.8°, 97.8° respectively. The Love station is located above the active fault zone that defines the southern border the Alandsky threshold of the Baltic Sea (between the Baltic and the Bothnic bay) and connected with the sub-latitude lineament by the southern border of the Central-Finland massif. The Leningrad station is located outside faults near the passive node of crossing of the latitudinal lineament of Neva river. The measured quiet geomagnetic field at the Love station located above the lithospheric deep fault is larger by 188 nT

than at the Leningrad station, located outside the fault (Figure 2a). This same trend remains for the disturbed geomagnetic field (ΔH = 189 nT, Figure 2b).

a)



b)

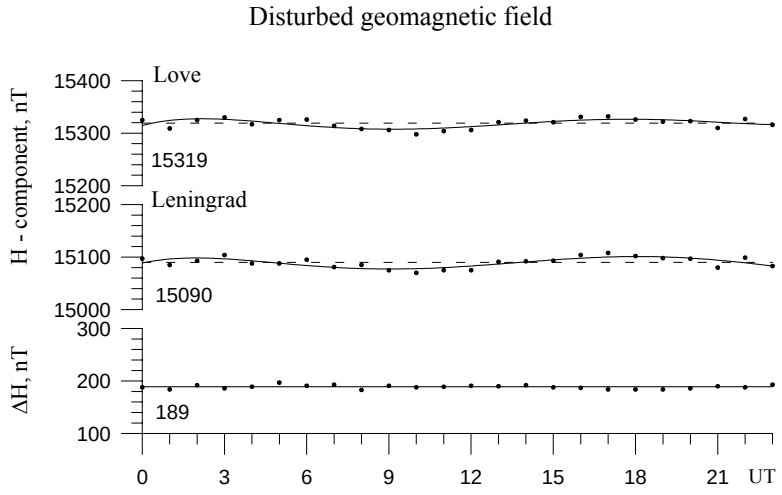


Figure 2**.** Daily variations of the mean hourly values of the horizontal geomagnetic field components (H) at the Love and Leningrad stations, and the difference (ΔH) between them for the March 1964.

Besides, by the value of excess one may give a qualitative characteristic of the activity of the deep fault. Since the lithospheric deep faults have different geodynamic activity, the difference between the H (X)-components measured at the two magnetic stations is the larger, the larger is the activity of the lithospheric deep fault. The analysis of the horizontal geomagnetic field components measured at a large number of the magnetic stations [*Orlov and Ivchenko*, 1971; *Golovkov and Dimant*, 1992] located over the different tectonic regions has shown that the above mentioned characteristic is quite persistent.

4. Conclusion

On the basis of the analysis of experimental data we detected:

- The horizontal geomagnetic field component at the magnetic station, located above the lithospheric deep fault is much larger, than at the magnetic station, located outside the deep faults zone. These two magnetic

stations must be located nearly on the same corrected geomagnetic latitude but above the different tectonic zones.

- The value of excess of the horizontal geomagnetic field component may give a qualitative characteristic of the activity of the deep fault.
- On the basis of the found regularities of the horizontal geomagnetic field components we propose a simple method for a detection of regional high fissuring zones and lithospheric deep faults [*Sergeeva et al*., 2002]. The proposed method does not require any considerable investment, since the available world network of magnetic stations can be used.

Acknowledgements. The authors are grateful to Dr. Johannes Kultima, who kindly provided the magnetic field data from the Sodankyla station.

References

Geomagnetic, Ionospheric and Auroral data from Sodankyla, Finland, April 1996, *The Finnish Academy of Science, published by Geophysical observatory Sodankyla*, 67, 1996.

Golovkov, V.P., and E.M. Dimant, Summary of annual mean values of the geomagnetic field at the world magnetic observatories network, *(Issue XXV), Russian Academy of Sciences, IZMIRAN, Moscow*, 12, 1992, (in Russian).

Gustafsson, G., N.E. Papitashvili, and V.O. Papitashvili, A Revised Corrected Geomagnetic Coordinate System for Epochs 1985 and 1990, *J. Atmos. Terr. Phys., 54*, 1609-1631, 1992.

Hakura, Y., Tables and maps of geomagnetic coordinates corrected by higher order spherical harmonic terms, *Rep. Ionosph. Space Res, Japan, 19*, 121-157, 1965.

Ionospheric and Geomagnetic data from Sodankyla Finland March, 1991, *The Finnish Academy of Science, published by Geophysical observatory Sodankyla*, 70, 1991.

Larkina, V.I., Yu.Ya. Ruzhin, N.G. Sergeeva, and B.V.Senin, Method for a detection of lithospheric zones of variable geodynamic activity, *Patent N 2158942*, The Priority of the invention is 29 October 1999, Registerd in the State Inventions Register of the Russian Federation *on 10 November 2000*, (in Russian).

Logachev, A.A., and V.P. Zaharov, Magnitorazvedka*, L., Nedra*, 351, 1979 (in Russian).

Migulin, V.V., V.I. Larkina, N.G. Sergeeva, and B.V. Senin, Reflection of lithospheric geodynamic processes in the ionosphere on the characteristics of electromagnetic emissions over active tectonic zones of the Baltic shield and the Barents-Kara shelf, *Doclady Academy Nauk*, *372, N5*, 673-678, 2000, (in Russian).

Migulin, V.V., V.I. Larkina, N.G. Sergeeva, and B.V. Senin, The comparative analysis of satellite electromagnetic effects above zones of tectonic faults, *Doclady Academy Nauk, 376*, 532-538, 2001, (in Russian).

Orlov, V.P., and M.P. Ivchenko, Summary of annual mean values of the geomagnetic field at the world magnetic observatories network 1960, *(Issue VI), Academy of Sciences, IZMIRAN, Moscow*, 50, 1971, (in Russian).

Sergeeva N.G., V.I. Larkina, and B.V. Senin., A method for detection of regional high fissuring zones and lithospheric deep faults data, *Patent N 2226283*, The Priority of the invention is 17 July 2002, Registered in the State Inventions Register of the Russian Federation *on 27 March 2004*, (in Russian).

Yanovskiy B.M., Terrestrial magnetism, *L.: published Leningrad University*, 591, 1978 (in Russian).