PRELIMINARY RESULTS OF EARTHQUAKE PRECURSORS SEARCHING IN GEOMAGNETIC DATA SERIES OBTAINED IN IZU PENINSULA IN 1997.

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Abstract

We newly analyze data series obtained in the Eastern part of the Izu Peninsula, Central Japan during 1997. We are searching for precursors to swarm earthquake M 5.0 – 5.3 occurred in the East Off Izu Peninsula on 3–4 March of 1997. Our method is based on factor analysis of geomagnetic data series and in contrast with former ones do not require experience with previous earthquakes. We analyzed data at stations situated inland far away from the swarm activity area. On the one hand that selection provides us low-noise data not contaminated with tidal effects. On the other hand possible tectonomagnetic signal may be not detectable at this area. At the recent stage of investigation we find out a specific pattern that may or may not be precursor to the earthquake.

1. Introduction

In situ observations have shown that definite changes in geomagnetic field accompany seismic events. As usual for signal detection simple differences between permanent stations and reference one are used (Oshiman et al., 1991, 1997; Sasai and Ishikawa 1991, 1997; Shapiro et al., 1994). The earthquake time forecast was based on character of geomagnetic field variations at one or more permanent stations, interpreted in the light of experience with previous earthquakes (Muminov and Berdaliev, 1982; Shapiro et al., 1994; Shapiro, 1998). Permanent stations are installed at specific sites due to assumption on nature of tectonomagnetic signal to be measured (e.g. piezomagnetic one or signals arose from varying electric currents in the earth), or simply nearly to previous earthquake epicentral position. However there is no completed theory of earthquake. In our study we follow the next hypothesis. In general, some physical processes caused earthquake have manifestation in geomagnetic field before and after an earthquake. After noise elimination differences between permanent stations and reference one represent only diversity due to spatial gradient of magnetospherical and secular variations (in tectonically and geomagnetically quiet periods) plus signal from some tectonic process, which we try to detect. Thus we have a lot of data series obtained at permanent stations and only a few reasons for them. As usual we can't observe reasons but only consequences. We should discover reasons analyzing consequences. On the other hand earthquake preparation process could have manifestation in one place and have not in other. Accordingly, there are two problems: (1) to discover reasons of observed data and (2) to find sensitive sites to catch useful signal. These are very the same problems solving by factor analysis. Namely, the main applications of factor analytic techniques are: (1) to *reduce* the number of variables and (2) to *detect structure* in the relationships between variables, that is to *classify variables* (Hartman, 1965; Statsoft, 2000). In the present paper we represent preliminarily results of factor analysis of geomagnetic data series obtained in 1997 at permanent stations located in the Eastern part of the Izu Peninsula. In 1997 first swarm earthquake activity began in Match and finished in April. The biggest earthquake M 5–5.3 was on 3–4 March (ERI, 1997). Second swam activity began on 25 June and continued until the end of the year; the biggest earthquake was M 2–3 (ERI, 1998).

2. Observational data

We analyzed daily mean night total force differences between permanent stations and Kakioka geomagnetic observatory. For a start we choose 6 stations, shown on Fig.1. Selection criteria were lowest noise level and absence of gaps in observations at the beginning of the year. To eliminate the influence of outliers and artificial disturbance on mean values we carried out following procedure. Firstly we selected data only at night hours, from 0 to 5 a.m. Then we calculated differences between minute values at a station and at Kakioka observatory. Next, for each day we excluded data, which is out of range ± 4 nT. Finally, we calculated daily mean values. The result is shown on Fig.2. There are several gaps on curves by reason of outliers or absent of data on one of the stations for the particular period.

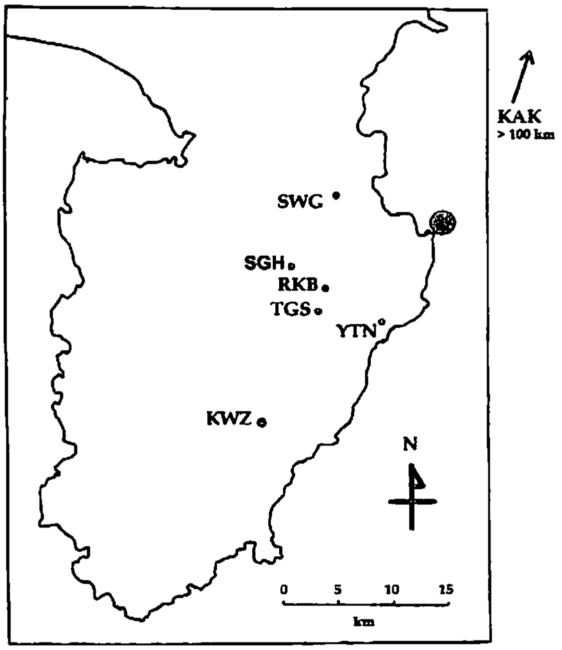


Fig.1. Locations of permanent stations used for the analysis. An arrow at the right side shows direction to Kakioka geomagnetic observatory, which used as a reference station. The darkened circle indicates central part of the swarm earthquake activity in March–April 1997. Center of the next swam activity located about 6 km to Northwest from the marked area.

3. Results

We carried out factor analysis on consequently increased data series starting from 10 days segments. Firstly we retained only factors with eigenvalues greater than 1. As a result we obtained only 1 factor in the entire analysis. Then we retained factors with eigenvalues greater than 0.3. In that case analysis gave extra factor at some dates. Thus second factor appeared for the following periods: Jan 17 – Jan 26; Feb 6 – Feb 13; Feb 22 – Feb 25; Mar 30 – Jun 15; Jul 18 – Aug 4; Aug 17 – Sep 10; Oct 20 – Nov 25. Factor loadings diagrams are shown on Fig.3 – Fig.5. These diagrams represent correlations between factors and variables (data series at a particular stations in our case). It should be noticed that there is a difference between factor loadings patterns before (Fig.3) and after (Fig.4, Fig.5) the biggest earthquake (M 5.0 – 5.3 occurred on 3– 4 March). To the end of January closed cluster contained of TGS, RKB, SGH are formed. Members of the clusters have high correlation (about 0.9) with the first factor and very low (about 0.3) with the second one. KWZ is located near to this cluster and differs from it in greater correlation with the first factor and less correlation with the second factor. YTN and SWG are completely separated. YTN have high correlation with the second factor and low with the first one. With insignificant changes this structure are kept until February 25. Then the second factor begins to appear from March 30 until November 25. Factor loading patterns are quite different for this period except the end of July and again, which are kept until the end of August (Fig.5). But in contrast with previous appearance it has lower correlation with the first factor (about 0.7) and higher (about 0.5) with the second one. It should be mentioned that KWZ now occupies almost the same position as before.

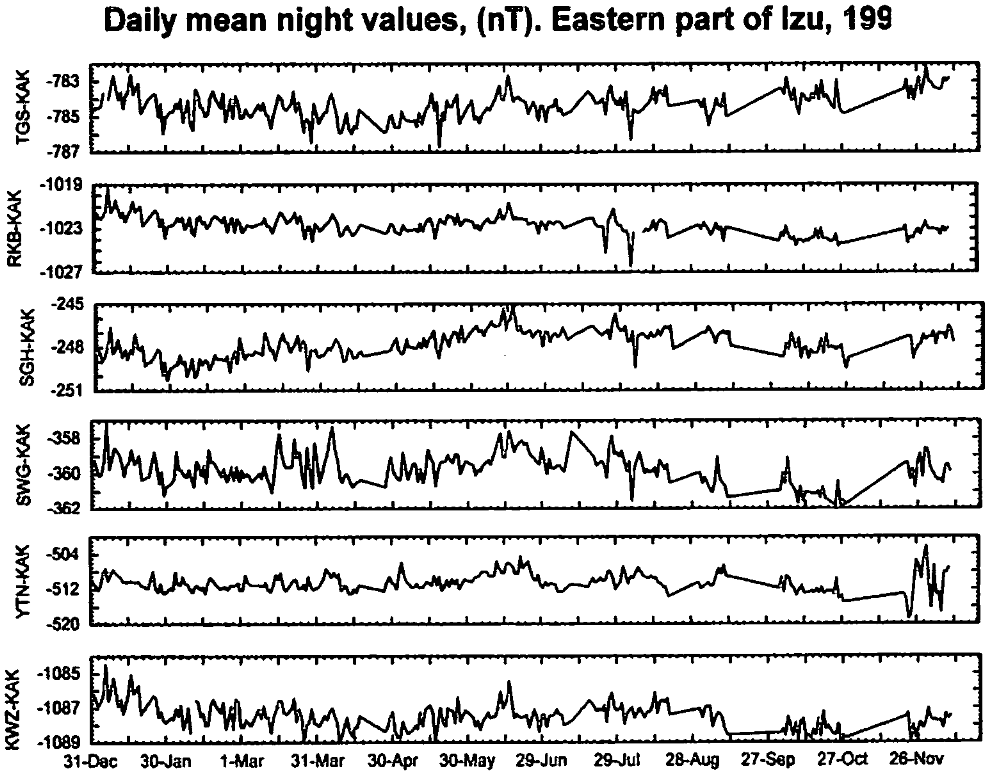


Fig.2.Total intensity variations during 1997 in the Eastern part of the Izu Peninsula used for the analysis. Daily mean values of night-time differenced data are plotted. Reference station is Kakioka geomagnetic observatory (KAK).

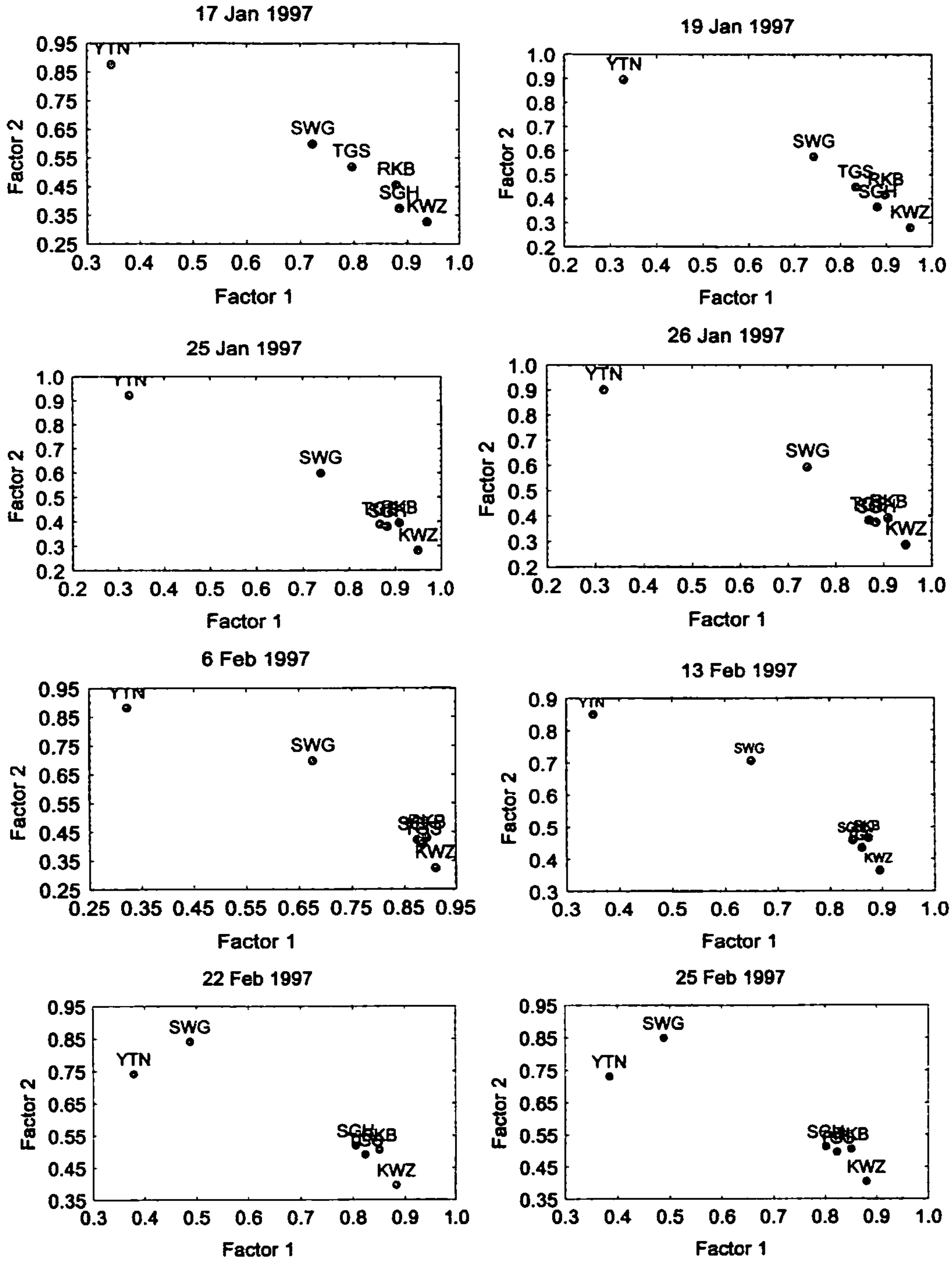


Fig.3. Factor loading diagrams prior to the biggest (M5.0–5.3) earthquake occurred on 3–4 March.

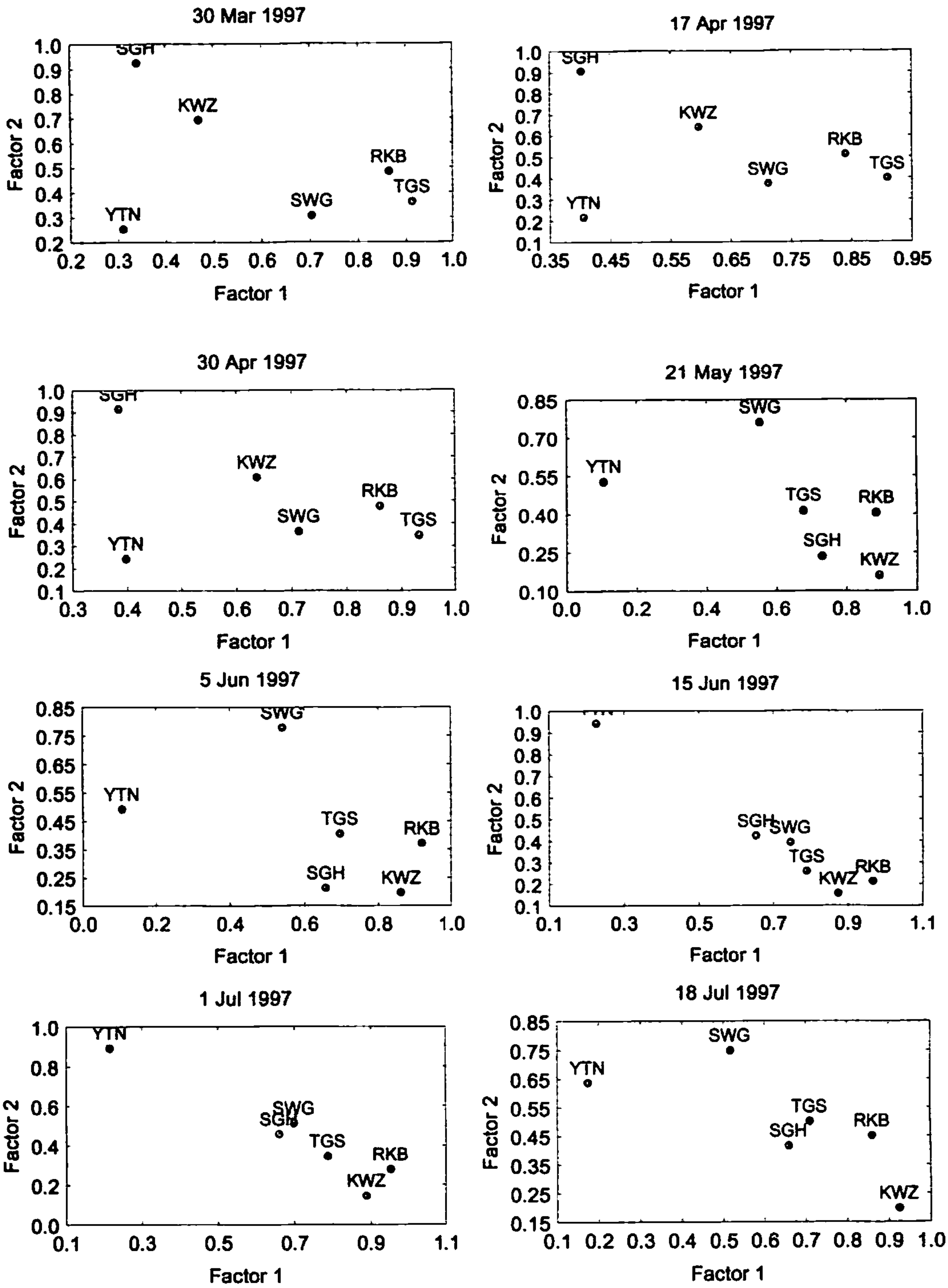
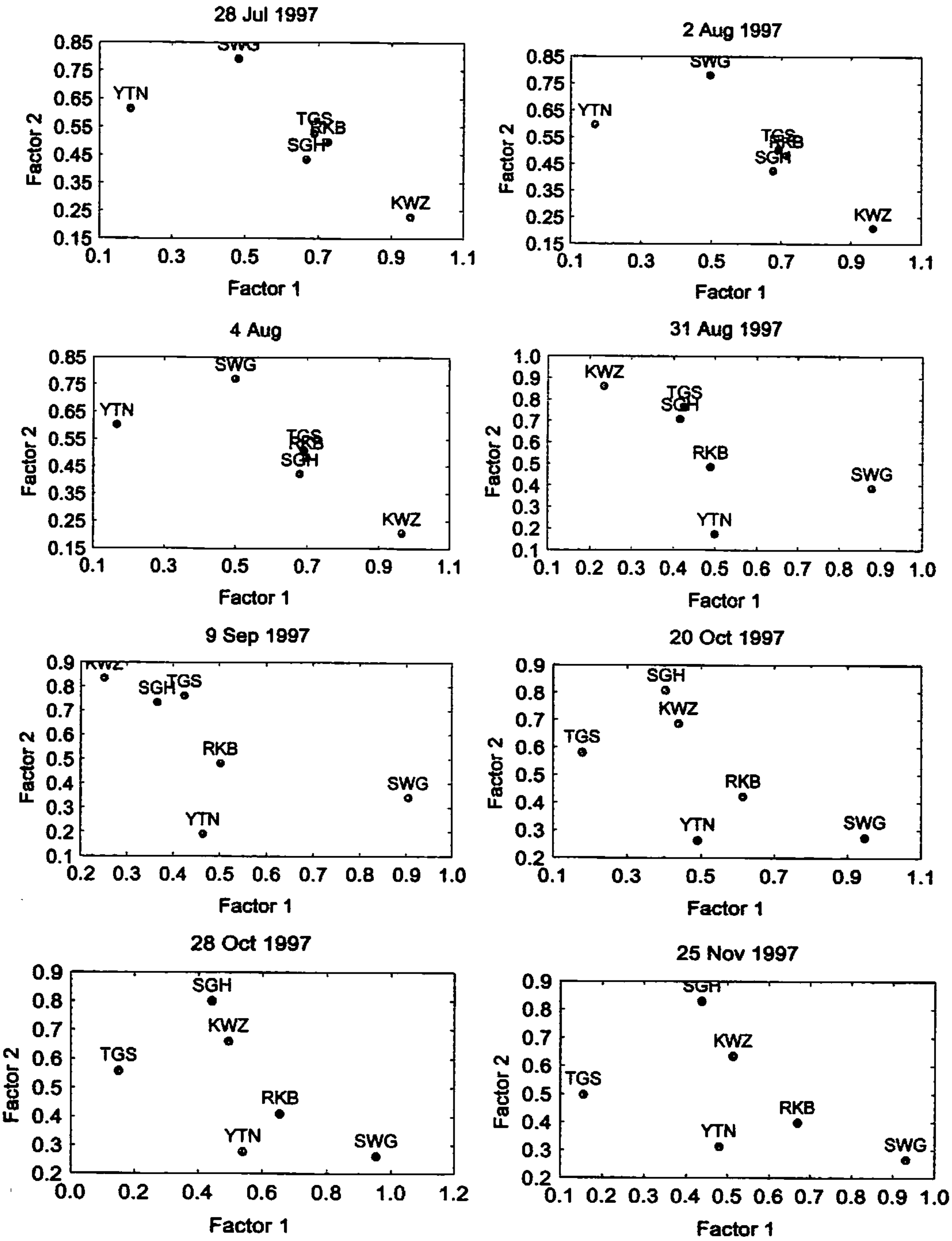


Fig.4. Factor loadings from April to July 1997.


28 Jul 1997

2 Aug 1997

4 Aug

31 Aug 1997

9 Sep 1997

20 Oct 1997

28 Oct 1997

25 Nov 1997

Fig.5. Factor loadings from August to November 1997.

4. Discussions and conclusion

Let us draw your attention to the factor analysis procedure once again. Factor analysis takes into account variance (or variability) of variables searching for the line on which the variance is maximal. This line becomes first factor. After we have found the line, there remains some variability around this line. To reiterate, we are extracting factors that account for less and less variance. The variances extracted by the factors are called the eigenvalues. The decision of when to stop extracting factors basically depends on when there is only very little "random" variability left. The nature of this decision is arbitrary; however, various guidelines have been developed (Statsoft, 2000). Due to the Kaser criterion (Kaiser, 1960) we should keep only factors with eigenvalues greater than 1. Other criterion is the scree test first proposed by Cattell (1966). Cattell suggests to find the place where the smooth decrease of eigenvalues appears to level off to the right of the plot. Scree plot corresponding to January 25 are shown on Fig.6.

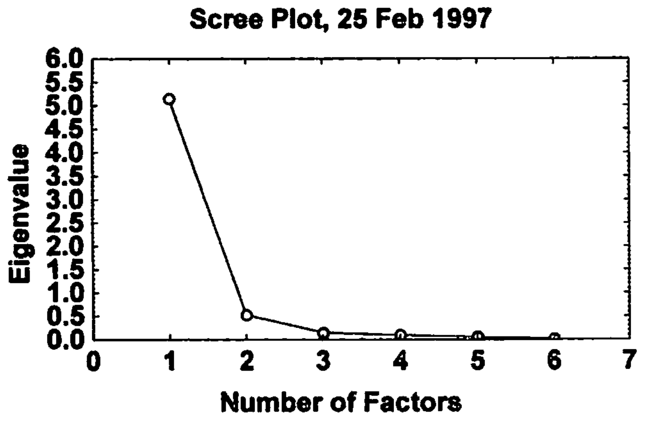

Scree Plot, 25 Feb 1997

Fig.6 Scree plot on 25 January.

One can see that maximal factors number is equal to number of variables used in the analysis. In resent analysis firstly we have kept factors with eigenvalues greater that 1 and received only one for data series of any length. It may be interpreted as absence of tectonomagnetic signals at selected stations. It should be mentioned that stations selected for analysis are far away from the earthquake swarm activity area. On the other hand there is small extra variability, which the first factor does not take into account. It allows us to extract the second factor and to classify observation stations. It turns out that closed cluster contains stations TGS, RKB, SGH, which are situated in the area of crustal uplift. SGH is situated near the uplift center (Sasai and Ishikawa, 1997). Second time the same cluster formed one month after the beginning of the next swam activity on 25 June. Thus, revealed pattern of factor loading may be or may be not time precursor. Additional stations situated near to earthquake swarm area should be used in the analysis.

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