ABSTRACT:

In this work, a new informatics program in 'C++' language for the separation of the regional and the residual anomaly is presented. The proposed approach lies on the limits observed in the former code of the potential data processing by the least square method (POLYFIT in FORTRAN 77 (Radhakrisna et al. 1990), GMSEP. PAS in PASCAL (Njandjock et al. 2003)). In order to make, it has established an algorithm thanks to a mathematical analysis that takes into account all parameters that the least square method implies. The validation of this program has been enabled by the comparison of its results with those of the former codes. The improvements on the treatment of a very big number of data and a separation at a high degree have been put in evidence by the gravimetric data processing of the zone of Yagoua at north Cameroon and with the same opportunity, it has been observed that these improvements permit a more pushed analysis of the structure with the determination of the features; more deep, least deep and those that spread of depths to surface.

KEY WORDS: Potential field; Mathematical formulation; Computer aspects; Data processing, Gravity, Magnetic. Residual, Regional.

INTRODUCTION

The potential field in a given point is the sum of the effects of the sources of anomaly weak, middle and very big depth or laterally distant. Thus, for a conformity interpretation with the geology of the region, it is imperative for the geophysicist to make the filtering of the reasons and sources of anomaly. Because, as MIKUS and JAMES (1991) showed it, the filters applied the information of a potential field make to take out again several interesting aspects. To make this filtering, several methods exist (the method by spectrum analysis; the calculation of the vertical and horizontal derivatives of the gravity; the method of the grids; the least square method; the graphic and visual process; the isostatic correction; the extension of the field upwards or toward...etc.). In the setting of our investigation, we constructed a potential information filter under the shape of a computer code in programming language 'C' thanks to the least square analytic method.

MATHEMATICAL FORMULATION

The separation of the deep or regional anomaly (REG) and the local or residual anomaly (RES) requires a regular regional. That is, it must have a slope that varies a little and corresponds to a continuous and derivable function (SCHOEFFLER, 1975). The regional anomaly can be represented therefore by an analytic function that admits a series of powers expansion. To determine this regional analytic surface, it is necessary to establish a mathematical model that binds the P(xi,yi) positions where the potential field B(xi, yi) is known and the regional analytic F(xi, yi). This can be made by polynomial interpolation.

The polynomial interpolation consists approaching the curve binding several sets of measures by a polynomial. The optimal coefficients of this polynomial being those that minimize the variance of the interpolation mistake (ε).
with \( \varepsilon_i = B(x_i, y_i) - F(x_i, y_i) \).

Since the polynomial to determine dregs three parameters \((F(x_i, y_i), x_i, y_i)\). It becomes:

\[
F(x_i, y_i) = c_1 + c_2 x_i + c_3 y_i + c_4 x_i^2 + c_5 x_i y_i + c_6 y_i^2 + \ldots + c_{M-N} x_i^N + c_{M-N+1} x_i^{-1} y_i + \ldots + c_M y_i^N
\]

with \(N\) the order of the polynomial and

\[
M = \frac{(N+1)(N+2)}{2}
\]

the number of term of the polynomial.

The equation (2) can also become

\[
F(x_i, y_i) = C_1 + \sum_{j=1}^{N} \sum_{j=0}^{N} C_m A_m(x_i, y_i)
\]

With \(A_m(x_i, y_i) = x_i^j y_i^j\) and \((C_m)\) is the coefficient of optimization of the polynomial. Or under the shape

\[
F(x_i, y_i) = \sum_{m=1}^{M} c_m A_m(x_i, y_i)
\]

If \((E)\) the quadratic gap and \((N_o)\) the number of \(P(x_i, y_i)\) stations where the potential field \(B(x_i, y_i)\) is known. We have

\[
E = \sum_{i=m}^{N} (\varepsilon_i)^2
\]

Taking into account that the adjustment of the surface analytic to the experimental surface consists to make minimal the quadratic gap, we have

\[
\frac{\partial E}{\partial c_k} = 0
\]

While combining (5) and (6) we get

\[
\sum_{i=1}^{N} \frac{\partial \varepsilon_i^2}{\partial c_k} = 0 \iff \sum_{i=1}^{N} \frac{\partial \varepsilon_i^2}{\partial c_k} \frac{\partial \varepsilon_i}{\partial c_k} = 0
\]

However

\[
\frac{\partial \varepsilon_i}{\partial c_k} = \frac{\partial (B(x_i, y_i) - F(x_i, y_i))}{\partial c_k} = A_k(x_i, y_i)
\]

Thus (7) becomes

\[
\sum_{i=1}^{N} [B(x_i, y_i) - F(x_i, y_i)] A_k(x_i, y_i) = 0
\]

While associating (4) and (8) we get

\[
\sum_{i=1}^{N} \sum_{m} C_m A_m(x_i, y_i) A_k(x_i, y_i) = \sum_{i=1}^{N} B(x_i, y_i) A_k(x_i, y_i)
\]
For (k) active of (1) to (m), the equation (9) generates a system of (m) equations with (m) unknown \( c_m \) therefore the shape is the following:

\[
\begin{align*}
\sum_{m=1}^{M} C_m \sum_{i=1}^{N_x} A_1(x_i, y_i) A_m(x_i, y_i) &= \sum_{i=1}^{N_y} B(x_i, y_i) A_1(x_i, y_i) \\
\sum_{m=1}^{M} C_m \sum_{i=1}^{N_y} A_2(x_i, y_i) A_m(x_i, y_i) &= \sum_{i=1}^{N_y} B(x_i, y_i) A_2(x_i, y_i) \\
\sum_{m=1}^{M} C_m \sum_{i=1}^{N_x} A_m(x_i, y_i) A_m(x_i, y_i) &= \sum_{i=1}^{N_y} B(x_i, y_i) A_M(x_i, y_i)
\end{align*}
\]

(10)

The system (10) can get under the following matrix shape:

\[
\begin{bmatrix}
\sum A_1 A_1 & \sum A_1 A_2 & \sum A_1 A_3 & \ldots & \sum A_1 A_M & C_1 \\
\sum A_2 A_1 & \sum A_2 A_2 & \sum A_2 A_3 & \ldots & \sum A_2 A_M & C_2 \\
\sum A_3 A_1 & \sum A_3 A_2 & \sum A_3 A_3 & \ldots & \sum A_3 A_M & C_3 \\
\vdots & \vdots & \vdots & \ddots & \vdots & \vdots \\
\sum A_M A_1 & \sum A_M A_2 & \sum A_M A_3 & \ldots & \sum A_M A_M & C_M
\end{bmatrix}
\begin{bmatrix}
\sum B_i A_1 \\
\sum B_i A_2 \\
\sum B_i A_3 \\
\vdots \\
\sum B_i A_M
\end{bmatrix}
\]

(11)

with \( A_m = A_m(x_i, y_i) \) and
\( B_i = B(x_i, y_i) \).

While solving this system by the method of ‘maximum Pivot of Gauss’, we get the coefficients of the polynomial \( F(x_i, y_i) \) that is equal to \( F(x_i, y_i) \) and to calculate the residual ‘RES(\( x_i, y_i \)’ by the relation

\[
RES(x_i, y_i) = B(x_i, y_i) - REG(x_i, y_i).
\]

(12)

**Algorithm of the Computer Code**

To solve the system (11) we put down an algorithm, of which the flow chart is:
Validation of the Program

After transcribing the algorithm in the programming language ‘C++’, we compared our result with those of GMSEP.PAS (Njandjock and al. 2003). So we took a sample of measures of anomalies of Bouguer on several points regularly distributed on a surface and proceeded with the separation with the two programs. That process gave us table (I).

We notice in this table (I), a big likeness between the results of the two programs that permits us to admit that our program fills in fact the function for which it had been conceived.

PUTTING IN EVIDENCE OF THE IMPROVEMENTS

To put in evidence of the improvements brought by the former programs, we separated the regional and the residual of the anomaly of BOUGUER in the region of Yagoua at the North Cameroon while using 1100 data and until the order 11 what the former programs didn’t permit fair. After the data processing, thanks to our code we got the cards of regional anomaly and anomaly to several orders of separation.

CONCLUSION

The previous survey led in the region of Yagoua that of Njandjock (2004), agrees with this work on the order (3) with the signature of the mass defect that corresponds to the root of the tooth of Mindif. But then, the shift between these two studies comes from the improvements brought codes of separation of the sources of anomalies. Unlike the previous survey that stopped on the order (3), this investigation evolves until the complete expression of the Bouguer in the regional analytic on the order (11). Thus, it is possible to make several observations that were not achieved in the previous survey. Among which we can mention:

- The progression of the regional analytic toward the Bouguer and the regression of the residual of this last at the total dislocation as the degree of the polynomial increases.
- The comparison of the depths of the structure features observed on the card of the Bouguer (face II-1). We have thus, the excesses of mass of the north of Maroua and Ouale lasso that go very at depth, because they appear on the regional at the order (6); the defect of mass of Moulvouday and the excesses of mass of Yagoua and Doukoulas that are less deep, one notes their presence from the order (9); the excess of mass of Kay Kay localizes itself a lot more in surface since its mark appears very late on the regional analytic on the order (11) and we observe it again on the residual at this order.
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<th>b(mGal)</th>
<th>res1(mGal)</th>
<th>reg1(mGal)</th>
<th>res2(mGal)</th>
<th>reg2(mGal)</th>
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b=anomalie of Bouguer  
res1=residual of program  
reg1=régional of program  
res2=residual of program  
GMSEP.PAS  
reg2=régional of program  
GMSEP.PAS
APPENDIX

New Code for Separation of Regional and Residual Anomaly of Potential Field

```c
#include "stdio.h"
#include "math.h"
#include "float.h"

main()
{
    const  n1=1000000,p3=191,v=10000;
    int i,j,k,m,n,m1,l,s,t1,t2;
    double b3,b33,b333;
    float x[v],y[v],b[v];
    double r3[v],r31[v],r32[v],a3[v];
    double d1[p3][p3],d[p3][p3];
    double e[p3],s3[p3],e[p3],c3[p3];
    // lecture des données dans le fichier d'entrée/
    FILE *FP;
    char nom_fichier[30];
    printf("entrez le nom du fichier d'entre: ");
    scanf("%s",nom_fichier);
    FP=fopen(nom_fichier,"r");
    for(k=1;k<=n;k++)
        r32[k]=0;r31[k]=0;r3[k]=0;a3[k]=0;
    for(i=1;i<=p3;i++)
        e[i]=0;e1[i]=0;s3[i]=0;
    for(i=1;i<=p3;i++)
        for(j=1;j<=v;j++)
            d[i][j]=0;d1[i][j]=0;
    t1=0;
    j=0;
    while(j<=m)
    {
        l=j;
        while(l>=0)
        {
            t1=t1+1;
            t2=0;
            k=0;
            while(k<=m)
            {
                s=k;
                while(s>=0)
                {
                    t2=t1+1;
                    i=1;
                }
            }
        }
    }
    fclose(FP);
    printf("entrez le nom du fichier de sortie:");
    scanf("%s",nom_fichier);
    printf("entrez le dégré du polynome");
    scanf("%d",m);
    FP=fopen(nom_fichier,"w");
    fprintf(FP,"%d
%d
",n,m);
    //initialisation des matrices de l'équation/
    for(k=1;k<=n;k++)
        r32[k]=0;r31[k]=0;r3[k]=0;a3[k]=0;
    for(i=1;i<=p3;i++)
        e[i]=0;e1[i]=0;s3[i]=0;
    for(i=1;i<=p3;i++)
        for(j=1;j<=v;j++)
            d[i][j]=0;d1[i][j]=0;
    t1=0;
    j=0;
    while(j<=m)
    {
        l=j;
        while(l>=0)
        {
            t1=t1+1;
            t2=0;
            k=0;
            while(k<=m)
            {
                s=k;
                while(s>=0)
                {
                    t2=t1+1;
                    i=1;
                }
            }
        }
    }
}
```
```cpp
while(i<=n)
{  
d[t1][t2]+=pow(x[i],(l+s))*pow(y[i],(j+k-l-s));
i++;
}
s--;
}
k++;
}

i=1;
while(i<=n)
{
    e[t1]+=b[i]*pow(x[j],l)*pow(y[i],(j-l));
i++;
}
i--;
}

//recherche du pivot maximal de gauss//
    m2=flot(m+1)*(m+2)/2;m1=m;m=int(m2);
j=1;
while(j<=m)
{
    i=1;
    while(i<=m)
    {
        d1[j][i]=d[j][i];
i++;
    }
    e1[j]=e[j];c3[j]=0;
j++;
}
k=1;
while(k<=m-1)
{
i=k+1;
while(i<=m)
{
    if(fabs(d1[i][k])>fabs(d1[k][k]))
    {
        j=k;
        while(j<=m)
        {
            s3[j]=d1[k][j];d1[k][j]=d1[i][j];d1[i][j]=s3[j];
j++;
        }
        b3=e1[k];e1[k]=e1[j];e1[i]=b3;
    }
i++;
}
i=k+1;
//triangularisation de L'équation//
while(i<=m)
{
    b33=e1[i]-d1[i][k]*e1[k]/d1[k][k];e1[i]=b33;
j=m;
    while(j>=k)
    {
        b33=d1[i][j]-d1[i][k]*d1[k][j]/d1[k][k];d1[i][j]=b33;
j--;
    }
}```
i++;
}
k++;
}
// calcul des coefficients //
c3[m]=e1[m]/d1[m][m];
k=m-1;
while(k>=1)
{
    j=k+1;
    while(j<=m)
    {
        c3[k]=c3[k]+d1[k][j]*c3[j];
        j++;
    }
c3[k]=(e1[k]-c3[k])/d1[k][k];
k--;
}
printf("\n coefficient values:\n");
i=1;
while(i<=m)
{
    printf("%f\n",c3[i]);
i++;
}
//printf("\n calculation of the residual A and the regional R:\n");
//printf("\n for the case of a regional of degree m:%d",m1);
//printf("\n separeted anomalies values:N,X,Y,bOUG,Res,Reg\n");
r3[1]=c3[1];
i=2;
while(i<=n)
{
    r3[i]=c3[1];
    if(x[i]!="0" && y[i]!="0")
    {
        t1=1;
        k=1;
        j=1;
        while(j<=m1)
        {
            k+=t1;
            r3[i]+=c3[k]*pow(x[i],j);
            t1+=1;
            j++;
        }
    }
    if(x[i]!="0" && y[i]!="0")
    {
        t1=1;
        k=1;
        j=1;
        while(j<=m1)
        {
            k+=t1;
            r3[i]+=c3[k]*pow(x[i],j);
            t1+=1;
            j++;
        }
    }
{  
  j=1;
  k=1;
  while(j<=m1)  
    {  
      l=j;
      while(l>=0)
      {  
        k=k+1;
        r3[i]+=c3[k]*pow(x[i],l)*pow(y[i],(j-l));  
        l--;
      }
      j++;
      }
  i++;
}

i=1;
while(i<=n)
{
  a3[i]=b[i]-r3[i];
  printf("%d	%f	%f
",i,b[i],a3[i],r3[i]);
  fprintf(FP,"%d	%f	%f	%f
",i,x[i],y[i],b[i],a3[i],r3[i]);
  i++;
}
fclose(FP);
  return 0;
}

CARTE OF ANOMALY OF BOUGUER AND REGIONAL AND RESIDUAL ON ORDERS  3,6,9 AND 11

Face (II-1): Map of the anomaly of Bouguer in the region of Yagoua.
face (II-2) : Map of the REG of degree 3

face (III-1) : Map of the residual of order 3

face (II-3) : Map of the REG of order 6

face (III-2) : Map of RES of order 6

face (II-4) : Map of the REG of order 9

face (III-3) : Map of the RES of order 9
face (II-5): Map of the REG of order 11

face (III-4): Map of the RES of order 11

REFERENCES


