Merging aeromagnetic data collected at different levels: the GEOMAUD survey

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Abstract

As part of the German GEOMAUD-expedition an aeromagnetic survey was carried out in Central Queen Maud Land. The helicopter-borne survey was designed in a conventional form of a regional survey with a spacing of profile-lines of 4.4 km. Due to terrain considerations – surveying from the coast across the mountain ranges to the high altitudes of the polar plateau – the survey was split into two sections flown at different constant levels. Over the coastal part survey elevation was 570 m (above sea level) while for the mountain section 2845 m was chosen. Both survey parts were processed separately. The low level section was upward continued before merging with the high level section. Though this leads to a homogeneous magnetic anomaly map, in some applications it may be more advantageous to present the anomalies of the magnetic field in original survey levels as a simple combined map because small scale features are preserved and can be used in recognizing magnetic units and patterns for geological/geophysical interpretation.

Key words *Queen Maud Land – Antarctica – aeromagnetics – magnetic anomaly maps*

1. Introduction

As part of the German GEOMAUD-expedition – carried out by the German Federal Institute for Geosciences (BGR) during the austral summer season 1995/1996 – a helicopter-borne aeromagnetic survey was conducted over the central parts of Queen Maud Land.

The scientific aims for the aeromagnetic survey can be briefly described as to recognize (and follow-up underneath the ice) the structural trends of the Precambrian basement and to define its boundary with younger tectonic features possibly related to the break-up of Gondwana.

Previous aeromagnetic surveys in Central Dronning Maud Land include the Indian survey carried out during the late 80's (Gupta and Verma, 1995) and widely spaced single aeromagnetic line data acquired by Russian expeditions (Karasik and Lastochkin, 1966). Due to uncertain absolute altitudes of the Indian survey, parts of the area were covered again with the future possibility of somehow linking both data sets.

2. Set-up of the survey

The survey was set up in the form of a conventional regional survey with a line spacing of 4.4 km and tie-lines being 22 km apart. Whilst the section over the ice-shelf north of the Schirmacheroase was flown at constant barometric altitude of 2000 ft (corresponding to 570 m a.s.l.

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as survey level), the section to the south covering the mountainous region was flown at 9800 ft (2845 m survey level) (fig. 1).

The «inland» section reached from the Schirmacheroase up to the edge of the polar plateau (about 170 km) and extended east-west over 300 km from the Filchnerberge in the west to beyond the Payergruppe south-east of the Wohlthatmassiv. Here we collected about 14800 line-kilometers of usable data over an area of more than 36000 km^2.

The northern survey section has an east-west extension of about 100 km and covers all the ice shelf up to 90 km north of the Schirmacheroase.

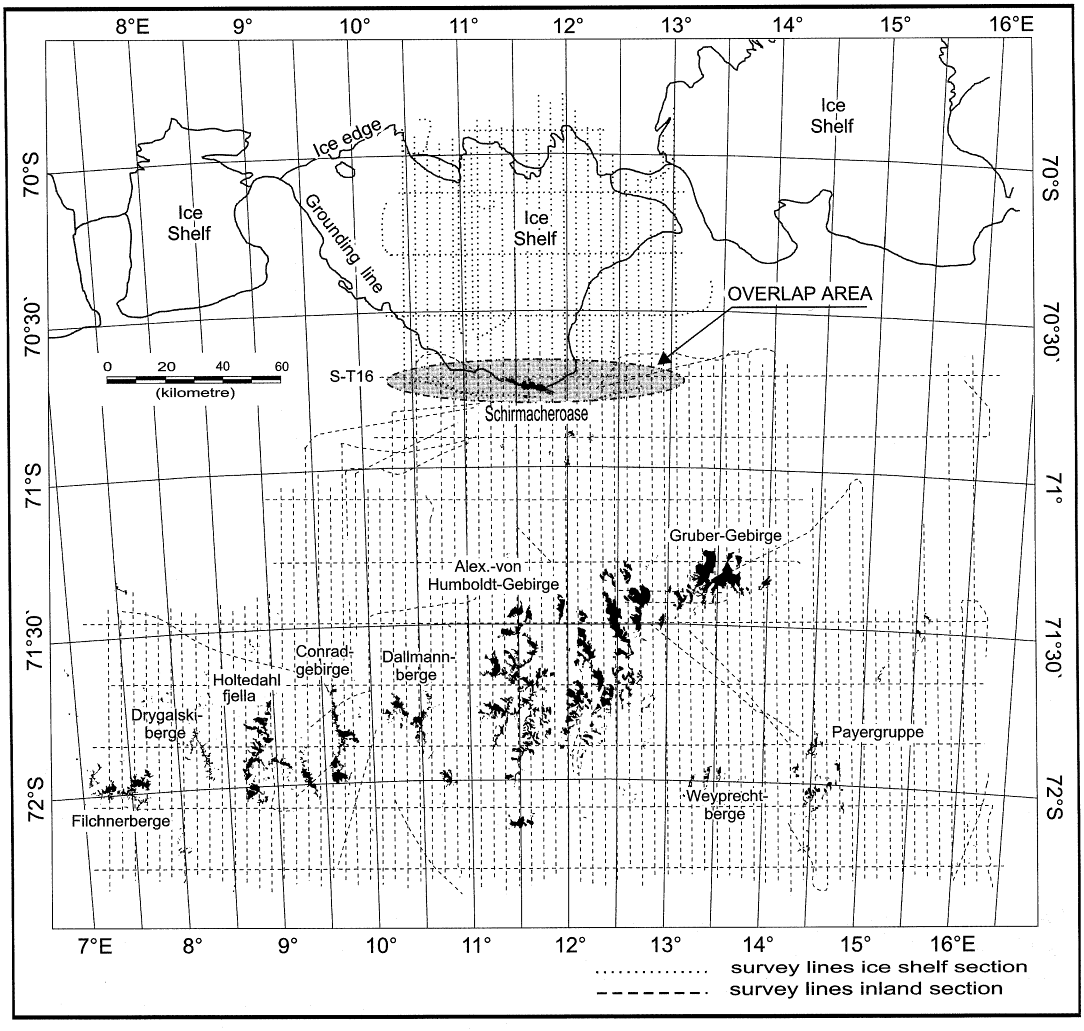

Fig. 1. The GEOMAUD aeromagnetic survey area in Central Queen Maud Land. Line labelled S-T16 marks the boundary between the low level survey area (sensor altitude 570 m) over the ice shelf in the north and the high level (2845 m) survey area over the mountains and towards the polar plateau in the south. The overlap area covers about 5-10 km to both sides of the line.

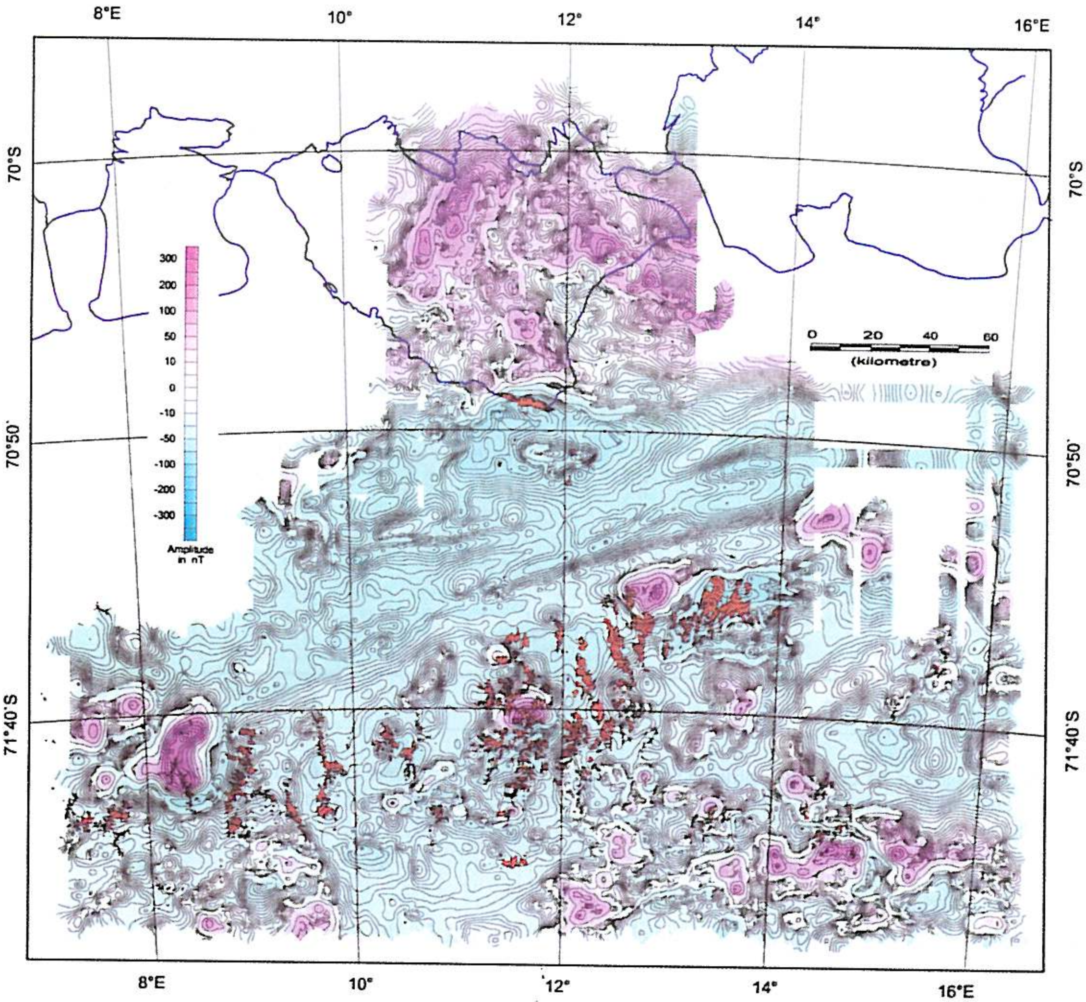

Fig. 2. Map of the anomalies of the total magnetic field derived from simple merging northern and southern survey grids in the original survey level (averaging grid values for the overlap area). Contour intervals are 10 nT. Place names are given in fig. 1.

More than 3100 km of line data over an area of approximately 8000 km^2 were collected.

In total, nearly 18000 km of profile- and tie-lines over an area of more than 44000 km^2 were available for processing and map production. The two sections at different survey levels have been processed separately, *i.e.* base station correction, IGRF-removal and the levelling process were done separately and two maps produced.

Both survey sections overlap to allow a merging of the data sets. The overlap area (fig. 1) plays an important role when judging the merging of both survey parts. At first sight, a simple merging by placing both survey parts side-by-side does not seem to be appropriate as the anomalies over the whole northern section show more positive values while in the adjacent part of the southern section negative values dominate (fig. 2).

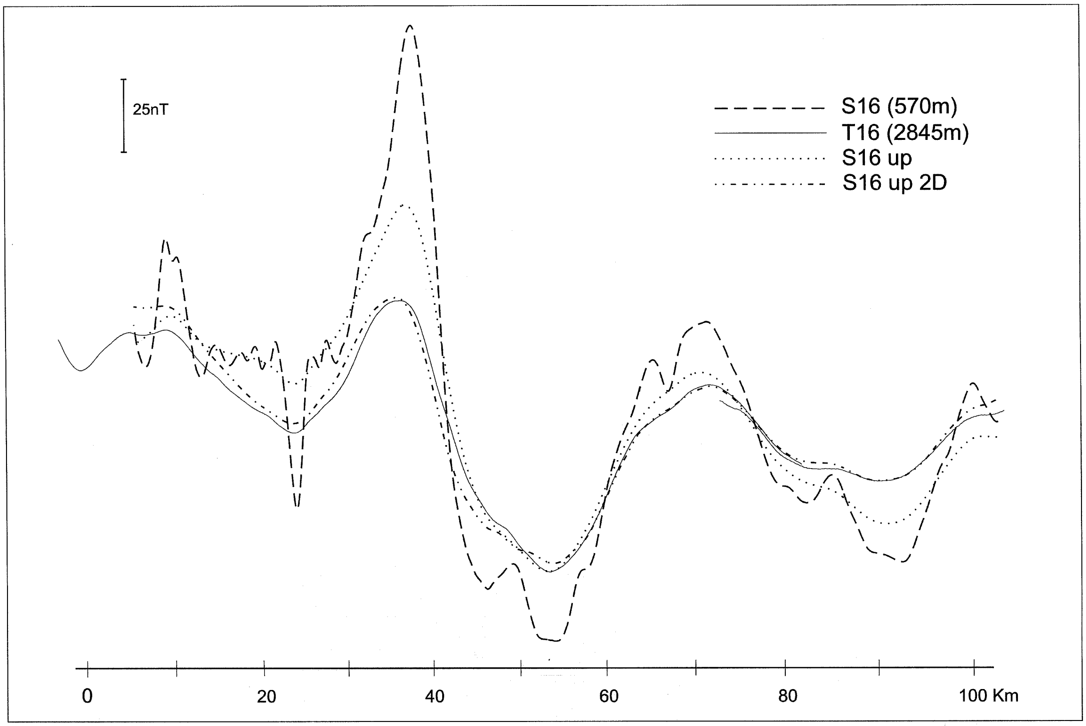

Fig. 3. Comparison of original profiles S16 (survey elevation 570 m) and T16 (survey elevation 2845 m) with upward continued single line S16up and line S16up2D sampled from upward continued overlap data. The scale is the same for all four lines.

3. Upward continuation of the low level survey

The southernmost tie-line of the low level section was flown at the same location as the western part of the northernmost high level tie-line. Therefore it is possible to directly compare single lines of the two survey levels. There are parts of other lines overlapping in the same way, but the tie-line S16 of the ice shelf section and the tie-line T16 of the inland section are by far the longest single lines to compare (see fig. 1).

Using the 1D Fast Fourier Transform (1DFFT) of the OASIS-GEOSOFT program package, line S16 has been upward continued from the 570 m flight level to the 2845 m level of the inland section. In the upward continued line S16up small scale features – which are present in the original line – are vanished or greatly reduced (fig. 3). However, compared to the high level survey line T16, some other features are preserved in the upward continued line and amplitudes seem larger. These differences make it doubtful whether a simple one dimensional upward continuation can give the result which we will get if collecting data in the higher level.

In a 2D approach the low level section was upward continued in grid form and compared to the high level section where they overlap. To avoid edge effects, only the central parts of the overlap area were used for comparison. The average difference between the upward continued and high level field was – 5.2 nT.

The line S16up2d was sampled from the upward continued grid and compared with the unchanged T16. This time the agreement was remarkable. If applying a shift of 5 nT – which is about the average difference for the whole «central» overlap block – the agreement is near to complete (fig. 3).

The simple conclusion we draw from this comparison is that upward continuing the whole low level grid will yield a result close to what is obtained if the whole area is surveyed in the higher level.

4. Merging the survey sections

Merging the two data sets of the survey sections flown in the high level and the upward continued low level produces a merged map which gives the impression of a «quiet pattern» in the north, totally different to a more «small scale anomaly pattern» in the south (fig. 4). This might lead to wrong interpretations as the smaller scale features in the northern part are lost.

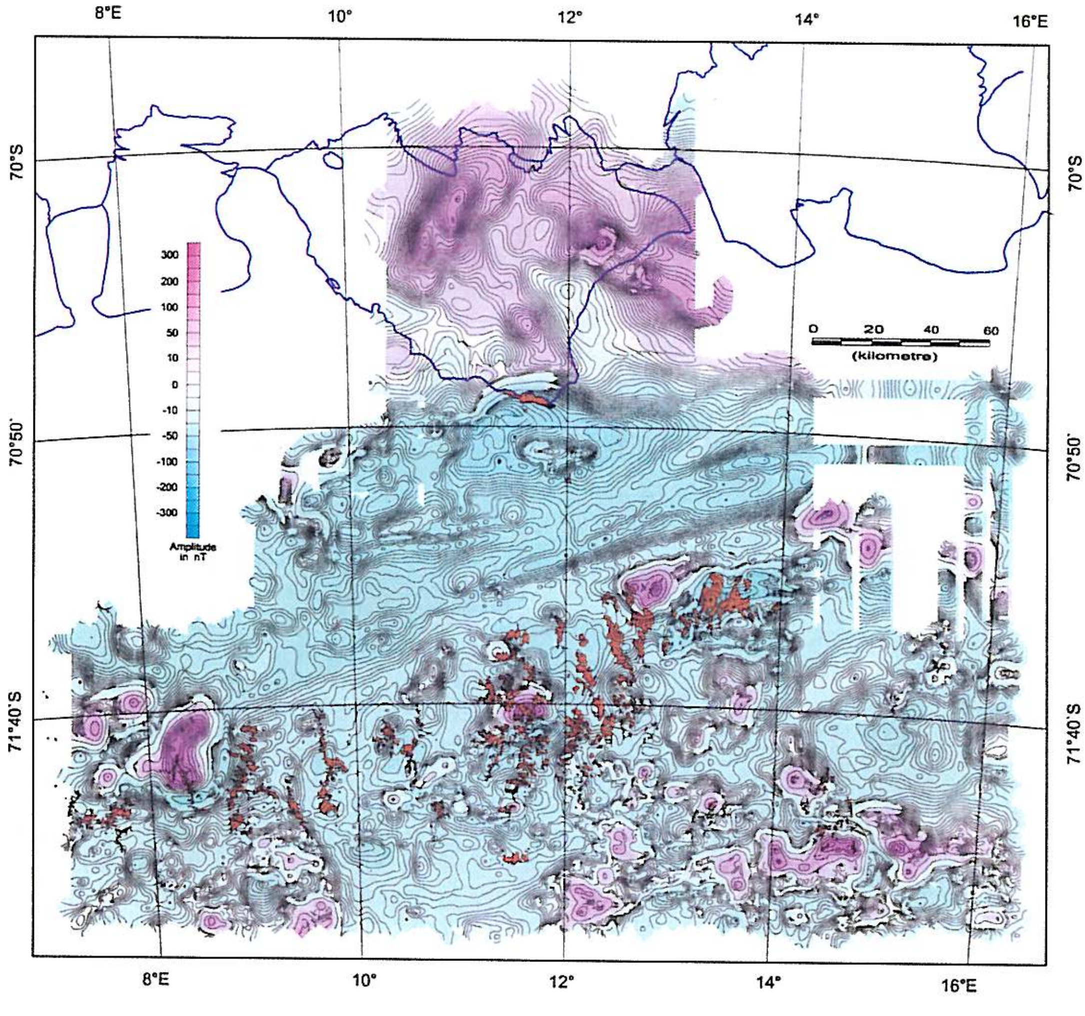

Fig. 4. Merged map of northern grid upward continued to 2845 m (survey level of the southern section) and the original southern grid. Contour intervals are 10 nT. Place names are given in fig. 1.

From the point of view of obtaining a homogeneous map one should upward continue not only the northern section, but also the southern one. This kind of map (fig. 5) reveals large scale features that are associated with magnetic sources of deep origin and which are continuous over some distance.

Because the objective of the survey was to follow trends and recognize magnetic patterns which can be related to geological features one has to check whether such a map (fig. 5) is still adequate to serve this purpose.

Some geologically significant features can still be recognized such as the magnetic lineament which extends all across the survey area from the southwestern to the northeastern limits. The area of the Gruberberge (for place names refer to fig. 1) – *i.e.* the large Anorthosite complex – is characterized by a large minimum, the strongest in the whole survey area which is

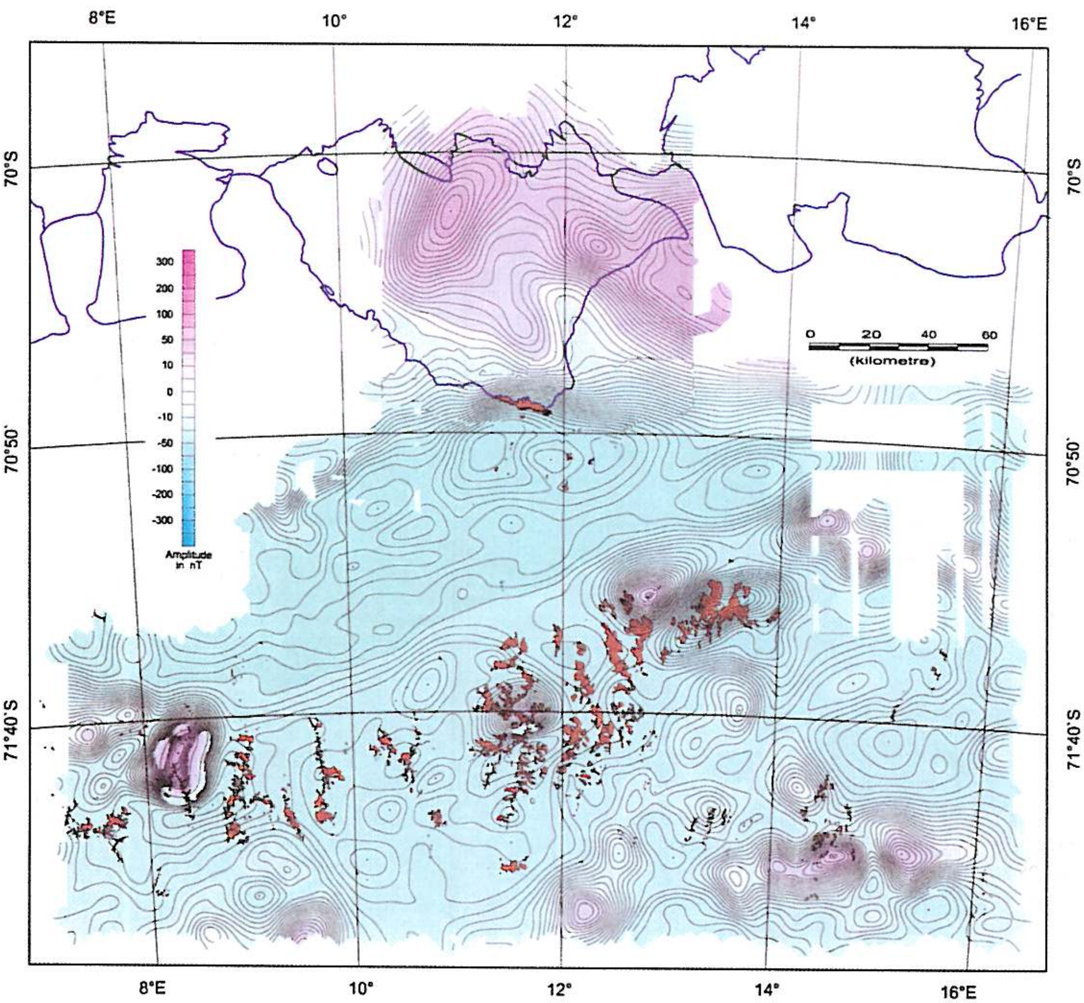

Fig. 5. Merged map for the whole survey area upward continued to a common level of 7000 m above sea level. Contour intervals are 10 nT. Place names are given in fig. 1.

preserved in the upward continued composite map. The remarkable positive anomaly (of about 1100 nT) is still an outstanding feature over the northern Drygalskiberge. Its extent points to a magnetic source at greater depth which not necessarily has to be correlated with surface geology. It is interesting to note that this anomaly somehow seems to disrupt the continuity of the SW-NE aligned magnetic lineament mentioned above, perhaps indicating a displacement in the basement.

Smaller anomaly chains extending from south of the Holtedahlfjella and Dallmannberge into the Alexander-von-Humboldt-Gebirge (see fig. 2) cannot be recognized in fig. 5. These are structures we were also aiming for, but are lost by the approach trying to obtain the most homogeneous map.

Over the shelf ice section north of the Schirmacheroase the two extended anomaly complexes are preserved (fig. 5). Lost are a number of small scale strong anomalies pointing to shallow sources in this area (compare with fig. 2). These shallow sources might be interpreted as volcanic layers of some extent which, if true, has a significant impact on the understanding of the tectonic development in this area.

All anomalies and all small scale structures are preserved in a presentation in which both survey areas are simply put side by side with the values in the overlap area calculated as the mean from both (fig. 2). By this the two areas «merge» more or less smoothly. We believe this to be the more adequate presentation for following up both the smaller scale magnetic pattern as well as the long wavelength features: nothing is lost only because of trying to come up with a homogeneous map.

Obviously it is difficult to treat such a map with mathematical procedures which need a homogeneous data base. At the boundary between the merged data sets problems will arise, but as one knows that there exists this survey boundary – and in the map it should be marked clearly – anything related to it has to be treated with caution. In the GEOMAUD case discussed here, we *do* have a strong boundary: the above mentioned apparent division into a more positive northern section and a predominantly negative area south of the section borderline – which gave rise to this discussion – is not an effect of the difference in survey level, but indeed indicates a boundary of geological nature.

5. Conclusions

Finally, what map one wants to come up with largely depends on the target. For following up near-surface geology it is necessary to keep as close as possible to the originally collected data as only these can provide the full information. Using upward continuation gives a more homogeneous map which might be easier to interpret for following features over a distance beyond a single survey. It is useful for long wavelength phenomena and deep seated structures. The scale of the final map may also play a role in the decision whether to upward continue and therefore «degrade» the data. For scales of less than 1:1 000 000 some small scale features can no longer be resolved in any case. For a composite presentation and for the goal of providing the best digital database to the community we recommend keeping as close as possible to the original survey values: for interpretation following the processing and initial presentation, one has to decide individually how the data are treated best.

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