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New Aspects of Crustal Structure in the Weddell Sea Region from Aeromagnetic Studies

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Summary: The Weddell Sea region is of crucial importance to understanding the structure and tectonic evolution of the Antarctic continent and its relation to the Gondwana assemblages. The most controversial questions are concerned with the original position of the Ellsworth-Whitmore Mountains crustal block before Gondwana separation and the recently proposed geological continuity between Laurentia and Gondwana during the Middle Proterozoic (the SWEAT hypothesis). Based on the Russian aeromagnetic data acquired in this region we present a possible evidence for the existence of Precambrian basement under a large part of the Weddell Sea Embayment and discuss other geological results of magnetic field structural interpretation.

In accordance with our interpretation the crystalline basement of the Haag Nunataks lies at least beneath the Ellsworth-Whitmore Mountains, the Ronne Ice Shelf up to 59 °W in the east and northward up to the ice-shelf break and southern Palmer Land. The Precambrian basement which outcrops in the Shackleton and Argentina Ranges most likely underlies the eastern Ronne Ice Shelf and Filchner Ice Shelf. Broad linear depressions in the surface of the magnetic basement over the eastern part of the Ronne Ice Shelf with two branches continuously traced in N-S and NE-SW directions may represent deeply-buried rift structures initially developed under the Weddell Sea Embayment admittedly since at least Early Paleozoic times.

Zusammenfassung: Die Region des Weddellmeeres ist von entscheidender Bedeutung für das Verständnis der Struktur und tektonischen Entwicklung des antarktischen Kontinents und seiner Beziehung zur Rekonstruktion von Gondwana. Bei den am kontroversesten diskutierten Fragen geht es um die ursprüngliche Position des Krustenblocks der Ellsworth-Whitmore Mountains vor dem Gondwana-Aufbruch und um die kürzlich vorgeschlagene geologische Verbindung zwischen Laurentia und Gondwana während des mittleren Proterozoikums (die SWEAT-Hypothese). Basierend auf russischen flugmagnetischen Daten aus dieser Region, präsentieren wir einen möglichen Nachweis für die Existenz präkambrischen Basements unter einem großen Abschnitt der Weddellmeer-Einbuchtung und diskutieren weitere geologische Resultate von strukturellen Interpretationen des Magnetfelds.

In Übereinstimmung mit unserer Interpretation liegt das kristalline Basement der Haag Nunataks zumindestens unterhalb der Ellsworth-Whitmore Mountains, des Ronne-Eisschelfs bis 59 °W im Osten und nordwärts bis zur Eisschelfkante und dem südlichen Palmer Land. Das präkambrische Basement, das in der Shackleton Range und der Argentina Range aufgeschlossen ist, liegt sehr wahrscheinlich unter dem östlichen Ronne-Eisschelf und dem Filchner-Eisschelf. Breite lineare Depressionen in der Oberfläche des magnetischen Basements über dem östlichen Teil des Ronne-Eisschelfs mit zwei Abzweigungen, die kontinuierlich in N-S- und NE-SW-Richtungen identifiziert werden, können tiefliegende Rift-Strukturen repräsentieren, die sich ursprünglich unter der Weddellmeer-Einbuchtung seit mindestens dem frühen Paläozoikum entwickelten.

INTRODUCTION

The Weddell Sea Province is of crucial importance to understanding the structure and tectonic evolution of the Antarctic lithosphere plate and its relation to the global geodynamic system. The importance of the Weddell Sea region crustal segment in a geodynamic context and for paleotectonic reconstruction is evident from its position at the Atlantic termination of a major intraplate suture, the Transantarctic discordance that forms a failed rift link between the Mid-Atlantic and West Pacific active rift systems. Defining the nature and behavior of the lithosphere at this crucial junction between intraplate failed rift crustal assemblages and the active boundaries of abutting plates is an inspiring geoscience problem. In such a complex tectonic region as the Weddell Sea Province, it is necessary to consider magnetic, gravity, seismic, paleomagnetic and geological information before trying to explain the crustal evolution of the area. The main problems in this region relate to the existence of oceanic crust beneath at least major parts of the present Filchner-Ronne Ice Shelf, subduction related geological structures along the eastern margin of the Antarctic Peninsula (AP) and the primary position of the Ellsworth-Whitmore Monntains (EWM) crustal block.

Geodynamic models, based primarily on paleomagnetic data, indicate translation of the EWM microplate from an original position off southern Africa, following 90° counterclockwise rotation during pre-Mid-Jurassic times (GRUNOW et el. 1987a,b) to its present position in West Antarctica (GRUNOW et el. 1991, GRUNOW 1993a). The most recent interpretations of paleomagnetic data (Grunow 1993b) suggest the existence of southwestern Weddell Sea Jurassic oceanic crust (up to 1000 km wide) and its subduction beneath the southeastern AP during the southward drift of the EWM. There is no obvious geological evidence for such a conclusion; sedimentation in the Latady basin is consistent with both extension at a passive margin, and extension behind a magmatic arc (STOREY et al. 1996).

Interpretations of deep seismic refraction data obtained by Russian and German expeditions suggest that extended continental crust underlies the Weddell Sea Embayment (WSE) (KADMINA et al. 1983, KAMENEV & IVANOV 1983, MILLER et al. 1984, KUDRYAVTZEV et al. 1987, HÜBSCHER 1994, HÜBSCHER et al. 1996a, JOKAT et al. 1997), with up to 14 km of sedimentary infill. At that time, aeromagnetic data allow to suggest, that the Ronne Ice Shelf is underlain by Haag Nunataks (HN) type Precambrian basement (MASLANYJ et al. 1991, ALESHKOVA et al. 1994). Airborne and satellite gravity data also evidence that a possible ocean-continent boundary between the Weddell Sea and WSE is located close to position of the prominent Orion Anomaly (LABRECQUE et al. 1986, BELL et al. 1990, ALESHKOVA et al. 1994, JOKAT et al. 1996).

STRUCTURAL INTERPRETATION

The WSE is clearly distinct from surrounding areas and shows low-amplitude, broad magnetic anomalies with wavelength up

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to 100-150 km. The observed magnetic anomaly pattern is largely due to the large tbickness of sediment strata which reaches 15 km in the central part of the WSE (KUDRYAVTZEV et al. 1987, LEITCHENKOV & KUDRYAVTEV 2000). There are some prominent magnetic anomalies, which provide clues to the nature of underlying basement. The aeromagnetic data provides additional information on the extent of the Haag Nunataks (HN) block. In accordance with interpretation of many authors (MASOLOV et al. 1981, GARRET et al. 1987, MASLANYJ et al. 1991, JOHNSON et al. 1992, ALESHKOVA et al. 1994, HUNTER et al. 1996) the basement underlying the Ronne Ice Shelf may be the same as the Precambrian basement exposed at Haag Nunataks. Our structural interpretation supports this theory and we suggest that the crystalline basement of the HN type may also lie beneath the Ellsworth-Whitmore Mountains, the Ronne Ice Shelf up to 59 °W in the east and northward up to the coast line and southern Palmer Land (see Fig. 6 in GOLYNSKY & ALESHKOVA 2000).

The origin of the magnetic anomalies of the southern Weddell Sea shelf is not immediately evident, they may have been caused either by infrastructural variations in the crust or by large volumes of magma intruded or extruded during the early stages of Gondwana rifting. Although our present knowledge is inadequate to draw any definite conclusions about the processes active at the southern Weddell Sea shelf and margin we may attribute the circular-shaped geometry of the magnetic features outlined over the southern Weddell Sea shelf to a rifted and/or down-fanlted crustal block which approximately corresponds to the General Belgrano Bank and may be considered as Late Proterozoic to Early Paleozoic in age.

Many features discernible in the magnetic and gravity patterns over the Filchner Ice Shelf together with bedrock topography information from multichannel marine reflection and deep seismic sounding data (KUDRYAVTZEV et al. 1987) are in accord with a rift interpretation as given earlier by GRIKUROV et al. (1980), MASOLOV et al. (1981). The character and distribution of the magnetic anomalies and Bouguer anomalies within the Filchner crustal zone developed along the East Antarctic craton margin is the result of several factors but appears to be related to an extensional regime which has dominated in the southern Weddell Province lithosphere since at least late Paleozoic time (GRIKUROV et al. 1991). They suggested that the basement of the central part of the rift structure was affected by high-density intrusions emplaced to mid-crustal level, causing demagnetization of rocks and producing negative magnetic anomalies. Some high-density and magnetic-rich bodies were probably emplaced into the upper crust along the deep faults parallel to the central part or the rift.

The most conspicuous feature of the aeromagnetic anomaly map of the Weddell Sea region is a wide curvilinear belt of positive magnetic anomalies running parallel with the coast of western Dronning Maud Land and Coats Land southwards to Berkner Island. It includes the Explora Anomaly, the Druzhnaya Anomaly and the Berkner Island Anomaly and marks the transition between the WS and EA magnetic zones (GOLYNSKY & ALESHKOVA 2000). Furthermore, magnetic anomaly data from the central sector of East Antarctica reveals that the magnetic anomaly belt running along Coats Land and western Dronning Maud Land could be extend from the Weddell Sea region towards Enderby Land (the Edward VIII Gulf) where it terminates (GOLYNSKY et al. 1996). It appears again eastward of the Prydz Bay region and possibly continues along the entire length of the Antarctic continental margin. This continental-scale anomaly belt was named as the Antarctic Continental Margin Magnetic Anomaly (ACMMA) by GOLYNSKY et al. (1996) and was interpreted to represent a rifted margin. Apparently it marks a continental crustal discontinuity formed during Gondwana break-up. The ACMMA has a width up to 120 km, with maxima of moderate to short-wavelength anomalies of 150-600 nT. The highest value of about 600 nT within the entire belt is found westward from the Gunnerus Ridge and is very high considering that aircraft was about 4.5-5 km above the possible sources. The belt is broadly curvilinear in shape, segmented and shows several changes in amplitude and pattern. The entire length of the ACMMA with its westward continuation in the Weddell Sea region, i.e. from the Edward VIII Gulf to the southern tip of Berkner Island is approximately 4300 km. It represents one of the longest continuous tectonic features in Antarctica. Its full extent was not mapped and there are two major gaps in the data. The first one is in the area between the Weddell Sea region and a survey located close to the Novolazarevskaja Station. The second one corresponds to the area located between the Novolazarevskaja Station and a survey completed eastward of 20 °E. Interestingly, the ACMMA roughly coincides with the continental slope and shelf areas over much of its length, although in the vicinity of the Novolazarevskaja Station it is observed partly over the onshore coastal area (Fig. 1). It clearly overlies continental crust of the Gunnerus Ridge. These examples provide additional evidence that the ACMMA can not be reconciled with an oceanic edge-effect interpretation. We suggest that the data are consistent with those interpretations that appeal to intrusive mafic or ultramafic rocks as the source of the magnetic effect.

Magnetic anomalies similar to the ACMMA are known worldwide and were considered by many authors as key elements of passive continental margins, though their origin is still debatable and remains a controversial problem (RABINOWITZ 1974, HALL 1990). In a first interpretation given by JOHNSON et al. (1992), the Explora Anomaly was associated with a volcanic sequence of seaward-dipping sub-basement reflectors (Explora Wedge), considered by HINZ & KRAUSE (1982) to be erupted on stretched continental crust during the late rift phase around the end of Mid-Jurassic times. LEITCHENKOV et al. (1996) attributed the Explora Anomaly to the integrated effect of the thick volcanic pile of the Explora Wedge and underlying intrusive dyke suite. More recently, LEITCHENKOV & MASOLOV (1997) suggested that the good correlation of the onshore and offshore magnetic lineaments implies that they can be considered as a common linear intrusive complex, emplaced into the continental crust in response to stretching. The dipping reflector unit is thought to comprise the same subaerially erupted Jurassic lavas as those seen on land (JACOBS et al. 1996). Therefore it is reasonable to expect a similar magnetic response for the two areas. Our observations clearly evidence that major magnetic anomalies in the Vestfjella are caused by gabbro intrusions, whereas basaltic lavas are characterized by low magnetic properties. Thus, it is unlikely that the volcanic wedge is responsible for generation of the Explora Anomaly.

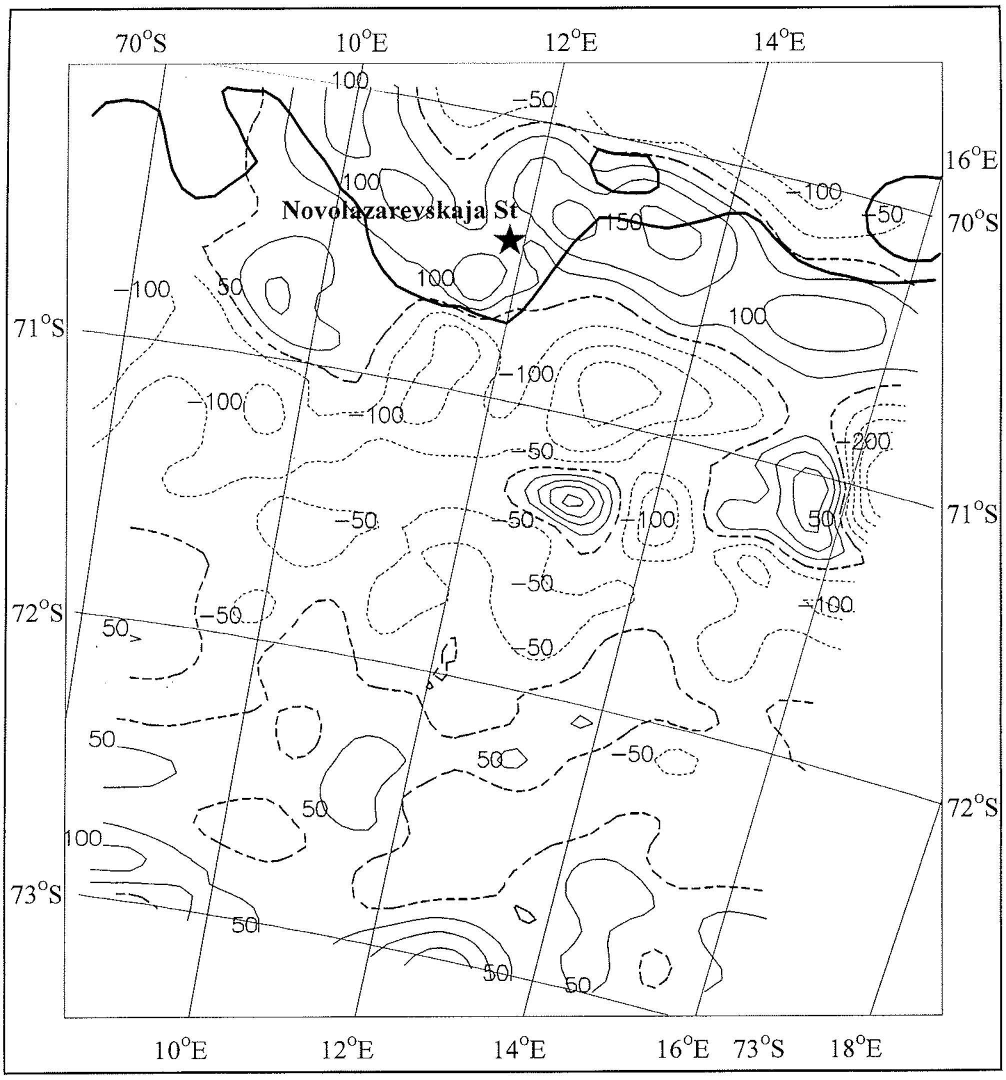

Fig. 1: Aeromagnetic anomaly map of the central part of Dronning Maud Land (contour interval is 50 nT).

Abb: 1: Karte der flugmagnetischen Anomalien des zentralen Dronning Maud Land (Konturenintervall 50 nT).

We have attempted to construct a model for the Explora Anomaly, but were unable to produce a magnetic model with a volcanic wedge that matched the observed field. The final magnetic model (Fig. 2) shows that the Explora Anomaly can be matched by introducing highly magnetic bodies (0.05-0.15 SI units) in the mid-crust of the transition zone. The only conclusion that we can draw from this model and on the basis of the magnetic anomaly grain is, that while a wide range of structures could be responsible for the EA we believe that it is produced by magmatic rocks intruded into the basement rather than volcanic sedimentary sequences forming the Explora Wedge and related to the initial rifting events of Gondwana separation. This is contrary to the HUNTER et al. (1996) interpretation that the entire magnetic anomaly belt from offshore western Dronning Maud Land southwards over Berkner Island is associated with the volcanic rocks, probably of a similar age to those of the Explora Wedge. At the same time, we support their suggestion that it is unlikely that a conventional mantle plume centered on the Karoo province could have produced such an extended zone of plutonism (volcanism). We favor an extensional origin due to rift-dynamical, non-plume processes, such as an enhanced convection.

Analysis of magnetic features within the entire belt (East Antarctica margin magnetic unit of the Weddell Sea magnetic zone) allowed GOLYNSKY & ALESHKOVA (2000) to suggest that many of them may be attributed with geological structures developed in onshore areas. This is obvious for the Coats Land crustal block and the Maudheim Province and to a lesser degree for the Shackleton and Argentina ranges and the Grunehogua Province. Therefore we believe that despite the overprinted character of the entire belt regarding the surrounding anomaly grain, its components are caused by the sources originated from different tectonic events during the evolution of the Antarctic continental margin in this region.

It is clearly visible on the structural map (Fig. 6 in GOLYNSKY & ALESHKOVA 2000) that some weak NW-SE structural features recognized as components of the Druzhnaya and Berkner anomalies and supposedly including anomalies of the eastern/central part of the Ronne Ice Shelf show structural trends colinear with those observed over the Shackleton and Argentina ranges and may provide evidence of their common origin. Alternatively, as was suggested by JOHNSON et al. (1992), magnetic lineations over the Ronne Ice Shelf may correlate with discontinuities at depth, possibly with faults in the magnetic basement. If this is the case, then it is reasonable to assume that these system of faults mark the western limits of the ancient structures of the Shackleton and possibly Argentina Ranges under the Weddell Sea Embayment.

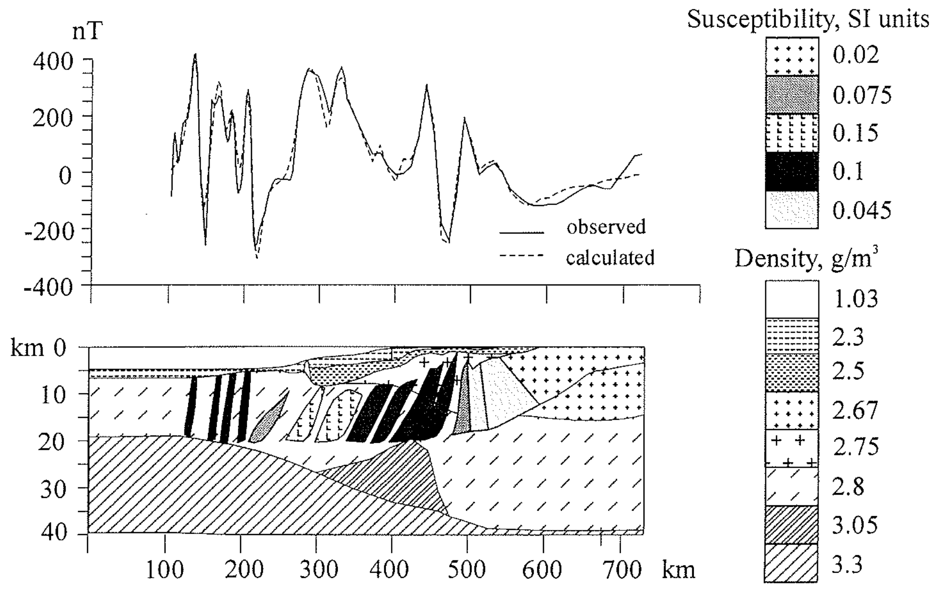

Fig. 2: Magnetic model across the western Dronning Maud margin (line 2 shown in Fig. 5) is based on DSS profile (KUDRYAVTZEV et al. 1991).

Abb. 2: Magnetisches Modell über den westlichen Kontinentalrand von Dronning Maud Land (Linie 2 in Abb. 5), basierend auf DSS-Profile (KUDRYAVTZEV et al. 1991).

The initial phase of the Weddell Sea sedimentary basin formation was during a period of thermal subsidence and subsequent rifting events that may have occurred along a boundary between the Haag Nunataks crustal block in the west and the inferred continuation of the East Antarctic Craton in the east. Subsequent multiphase extensional episodes in this part of the WSE probably led to the formation of the system of horsts and grabens although these are not discernible by deep seismic observations conducted along the ice-shelf break of the Ronne and Filchner Ice Shelves (KUDRYAVTZEV et al. 1987, HÜBSCHER et al. 1996a, KUDRYAVTZEV & LEITCHENKOV 2000). At that time, a broad linear depression in the surface of the magnetic basement (Fig. 8 in GOLYNSKY & ALESHKOVA 2000) over the eastern part of the Ronne Ice Shelf with two branches in the N-S and NE-SW directions suggest that these graben-like features may represent the deeply-buried rift structures initially developed under the WSE originally in Early Paleozoic time. The Y-shaped spatial geometry of the observed depressions provides indirect evidences that features in the relief of the magnetic basement may be interpreted as a rift system or a rift-rift-rift triple junction, the center of which is located at approximately 77 °S, 51 °W.

The eastern branch of the WSE rift system for the most part of its length is coincident with a linear magnetic low running southwards from the continental rise to the coast-line and forming one of the most striking features of the WS magnetic zone. This low partly correlates with a positive free air gravity anomaly and with the location of a basement depression flanked on its landward side by the Explora Wedge and on its northern side by dipping sub-basement reflectors of the Andenes Escarpment (HINZ & KRISTOFFERSEN 1987). This allowed HINZ & KRISTOFFERSEN (1987) to interpret the depression as a narrow failed rift.

The western arm of the WSE rift system has no distinct magnetic signature. It is associated with predominantly negative and/or subdued magnetic anomalies of different orientations and corresponds to the area located between the Antarctic Peninsula in the west and the crustal block located approximately over the General Belgrano Bank and surrounding areas (GOLYNSKY & ALESHKOVA 2000). Therefore our observation suggest that the WSE rift system initially developed either along boundaries of differently composed Precambrian crustal blocks or it might have used preexisting zones of weakness or/and older rift structures (Middle to Late Cambrian) reactivated during the Mesozoic. Apparently, the failed rift of HINZ & KRISTOFFERSEN (1987) is developed along an older rift structure.

Cambrian rift sequences are not unique to this part of West Antarctica. Geochemical analysis of Middle Cambrian magmatic rocks and detailed structural examination of the stratigraphy suggest that the Ellsworth-Whitmore Mountains crustal block was situated in a continental rift setting during the Middle to Late Cambrian times (CURTIS 1998). This is similar to the situation in the Pensacola Mountains where turbidite sedimentation may be an argument for a continental margin setting as opposed to a continental rift environment (TESSENSOHN 1997). It is currently unclear what the relationship is between geologically known areas of crustal extension during Cambrian-Ordovician times and those possibly buried under the WSE. They may have been extensively modified during subsequent extension episodes. This problem remains to be solved by future geological and geophysical investigations. At present, it seems rather obvious that the linear magnetic anomaly together with accompanying negative flanks running parallel with the boundary of the Haag Nunataks crustal block from the eastern extremity of the Heritage Range, through the area between Korff Ice Rise and Henry Ice Rise towards the ice-shelf break is genetically related with the Ellsworth Mountains, and possibly represents the major crustal suture between East and West Antarctica.

In our view, aeromagnetic data as well as other geophysical observations (HÜBSCHER et al. 1996, JOKAT et al. 1997) do not support the plate reconstructions for West Antarctica described from paleomagnetic data (GRUNOW et al. 1991, DALZIEL & GRUNOW 1992). The generally accepted pre-break-up position of the EWM crustal block together with the Haag Nunataks block is outboard of the Falkland Plateau and southern Africa. Comparison of the magnetic anomaly patterns in the Natal Province (Fig. 1 in CORNER & GROENEWALD 1991), and the Haag Nunataks and western DML areas (Fig. 1 in GOLYNSKY

& ALESHKOVA 2000) casts doubt on the idea of a continuous Namaqua-Natal-Falkland-Haag-Dronning Maud Land belt, interpreted by GRANTHAM et al. (1997) in terms of an island arc-setting. There is an inconsistency of major trends of the HN block magnetic anomalies restored in a paleoposition within the Natal Embayment with those in counterpart regions. Furthermore, aeromagnetic data and gravity observations over southern Palmer Land allowed GOLYNSKY & MASOLOV (2000) to suggest that the area between the Evans Ice Stream and the Behrendt Mountains is underlain by the non-magnetic equivalent of the Haag Nunataks basement, similar to that inferred for the Ellsworth Mountains. The existence in this area of the Mid-Paleozoic? FitzGerald quartzite beds and Permian sedimentary rocks of the Erehwon beds, which were correlated with Devonian Crashsite quartzite, and Polarstar Formation of the Ellsworth Mountains respectively (LAUDON & CRADDOCK 1992) apparently is in agreement with our interpretation. This implies that at least starting from Paleozoic time three crustal blocks (EWM, HN and AP) formed single rigid block. Paleomagnetic data for the AP and EWM are consistent with these blocks being adjacent at 175 Ma (GRUNOW et al. 1987b) and do not rule out an independent motion of the Antarctic Peninsula and EWM blocks (GRUNOW et al. 1993a, b). Therefore, it is unclear at the moment what rifted off the southern African-Weddell Sea sector of Gondwana.

The oceanic-continental boundary is usually thought to be best defined by seismic data. However, permanent sea ice in the Weddell Sea and technical limitations prevent the definition of deep continental and oceanic crust with great spatial resolution. In this respect information derived from analysis of potential fields may help to constrain the transition from continental to oceanic crust. The continuity of the Orion Anomaly suggests that this anomaly marks an important crustal boundary (or zone of igneous material) and is fundamentally related to a syn-rifting or early post-rift period of the margin, while it contrasts with the distinctly different structures inferred from the gravity modelling across the margin (ALESHKOVA et al. 2000, BELL et al. 1990). The source of the Orion Anomaly, according to the interpretation of LABRECQUE et al. (1986, 1989) is a volcanic pile at the ocean-continent boundary of the southern margin of the Weddell Basin. Comparing the position of the gravity anomaly „edge effect“ and the OA shows that they are not directly coincident and may not be related (ALESHKOVA 2000). At that time, free-air gravity anomalies, derived from re-tracked Geosat and ERS-1 radar altimeter data clearly show that a scarp-like feature in satellite gravity field coincides with the OA (MCADOO & LAXON 1996). They believe that this feature can be considered as a fracture zone or a scar left by a ridge jump during the early opening of the Weddell Sea in the Mesozoic.

The southern margin of the Weddell Sea is marked by a broad (up to 120 km) curvilinear zone of negative anomalies (magnetic through) running parallel with the OA. This pronounced zone is only partly shown in the westernmost part of the map based on aeromagnetic data collected by Russian scientists (Fig. 2 in GOLYNSKY et al. 2000), whereas its full extent is well defined by the USAC data (LABRECQUE & GHIDELLA 1997, GHIDELLA & LABRECQUE 1997) as far as 24 °W in the east. Here, this anomaly terminates fairly abruptly and its continuation is unclear. The OA and negative anomaly apparently terminate in the vicinity of the Polarstern bank (PSB) (MILLER et al. 1991), interpreted as a seamount, which is characterized by a pronounced positive anomaly of 630 nT at its northern part (JOKAT at al. 1996). It was suggested that the region between the northern tip of the PSB and the southern seamount is underlain by oceanic crust (JOKAT et al. 1996). A hot spot was assumed to be responsible for the development of the bank. According to these authors, the PSB is a seamount chain related to the same volcanism as in Vestfjella. It is difficult to accept this interpretation because the basaltic flows of Vestfjella are mainly characterized by low magnetic properties, therefore we prefer the interpretation of the PSB given by MILLER et al. (1991) who interpreted it as a delayed crustal intrusion in the northern continuation of the rift axis.

The magnetic anomaly pattern north of the curvilinear low is subdued (Cretaceous normal polarity Superchrone, 83-118 MA) with anomalies rarely exceeding 50 nT in amplitude (LABRECQUE & GHIDELLA 1997, GHIDELLA & LABRECQUE 1997), they are difficult to correlate over distances of more than about 100 km. These anomalies appear to strike approximately W-E, sub-parallel to the sea-floor spreading magnetic anomalies to the North, with the outstanding magnetic anomaly C34 (83 Ma) clearly identified throughout the Weddell Sea during the NW-SE spreading phase (LABRECQUE & BARKER 1981). In an initial interpretation of marine magnetic data LABRECQUE & BARKER (1981) suggested that this part of the Weddell Sea contained oceanic crust of Mid-Jurassic age (M20 to M29), which would be some of the first ocean floor formed during the break-up of Gondwana. However, this interpretation has not subsequently been substantiated by later workers.

Recent analysis of the Weddell Sea magnetic anomaly data (LIVERMORE & HUNTER 1996), in the light of the new satellite gravity map, provides new constraints on plate kinematics prior to chron C34. According to their interpretation, M-series anomalies cannot be identified with confidence between C 34 and a linear high (Anomaly-T) associated with the southern termination of a "herringbone" pattern of gravity ridges and troughs. Farther south of "Anomaly-T" the magnetic anomalies show a resemblance to anomalies M4-M12 formed during NE-SW spreading at the South America-Antarctica plate boundary. They concluded that previously identified features, such as the Orion, Explora and Andenes anomalies, and the Polarstern Bank, all characterized by magnetic anomaly highs, can be attributed to excess volcanism during early break-up.

We cannot rigorously test the LIVERMORE & HUNTER (1996) model and have some doubts that the presented model of the plate tectonic evolution is completely valid and in good agreement with the existent data sets. The assumption that the early phase of spreading occurred in the NE-direction as a result of earliest motion between West and East Gondwana is not supported by the observed trends of magnetic anomalies, which stretch roughly W-E not in the NW-SE-direction required. Another unsolved question is why all the magnetic lineations of the Weddell Sea have one starting point (63 °S, 49 °W) south of the Powell Basin? Additional unexplained events are: a) the kinematics motion of the Antarctic Peninsula crustal block relative to the East Antarctica to avoid the overlapping between the Antarctic Peninsula and South America plates; b) subduction of the South America – Antarctica spreading center under the Scotia and Sandwich plates.

Speculative interpretations of the nature of the transition zone between oceanic and continental elements are highly dependant upon tectonic models. The ocean-continent boundary transition has been suggested as the source of the OA which has a magnetic signature similar to that observed at the volcanic passive margins (LABRECQUE et al. 1986, GHIDELLA & LABRECQUE 1997). In some models (e.g. KRISTOFFERSEN & HAUGLAND 1986, KRISTOFFERSEN & HINZ 1991) the continent-ocean boundary is placed at the foot of the present continental slope. JOKAT et al. (1996) believed that the transition runs parallel to the South of the EE and AE and is marked by a positive free air anomaly (50-100 mGal) along the 500 m shelf break. LIVERMORE & HUNTER (1996) combined Africa-Antarctica and South America-Antarctica plate rotations and pointed out that the trends of flow-lines observed on satellite gravity maps can be approximated by assuming that the Weddell Sea floor north of 72 °S was created entirely by South America - East Antarctica separation. A consensus view on the location of the continental-ocean boundary has not been reached at the moment. Further observations including high-resolution seismic studies accompanied by magnetic/gravity profiles are needed to determine its true location.

Results of our studies based on the modeling of potential field data indicate a change from thinned continental crust beneath the continental shelfslope break to a crust with more oceanic affinities beneath the adjacent Weddell Sea. The model for the profile crossing the Andenes plateau presented on Figure 3 clearly shows that a crustal thickness of at least 18-20 km

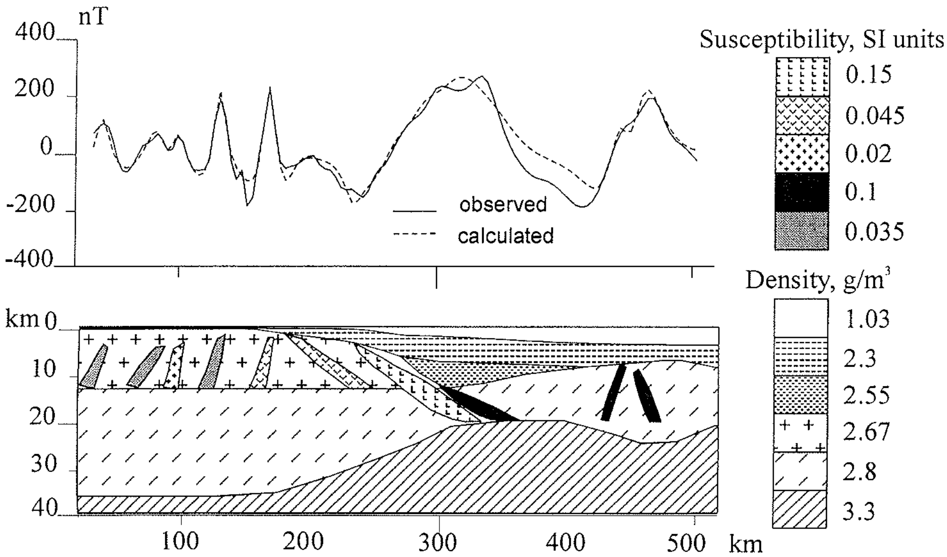

Fig. 3: Magnetic model across the suggested Failed Rift in the southern Weddell Sea. Location of the aeromagnetic profile 3409 used for modelling shown in Fig. 5.

Abb. 3: Magnetisches Modell über das vermutetete "failed rift" im südlichen Weddellmeer. Die Lokation des flugmagnetischen Profils 3409 ist für die Modellierung in Abb. 5 benutzt worden.

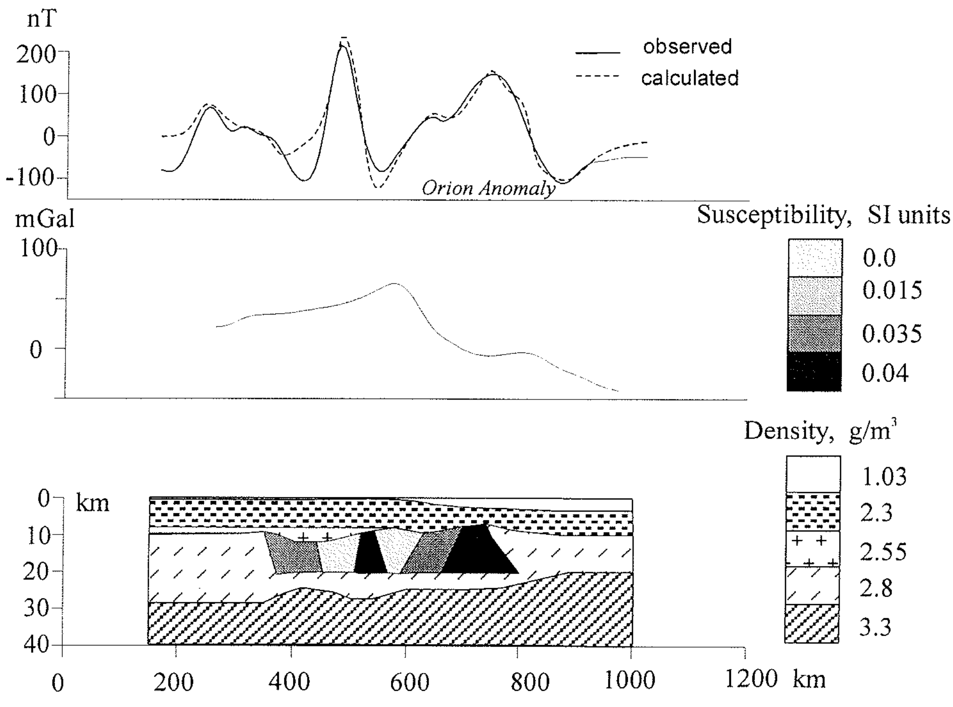

Fig. 4: Magnetic model across the western Weddell Sea margin (Line 1 shown in Fig. 5)

Abb. 4: Magnetisches Modell über den Kontinentalrand des westlichen Weddellmeeres (Linie 1 in Abb. 5).

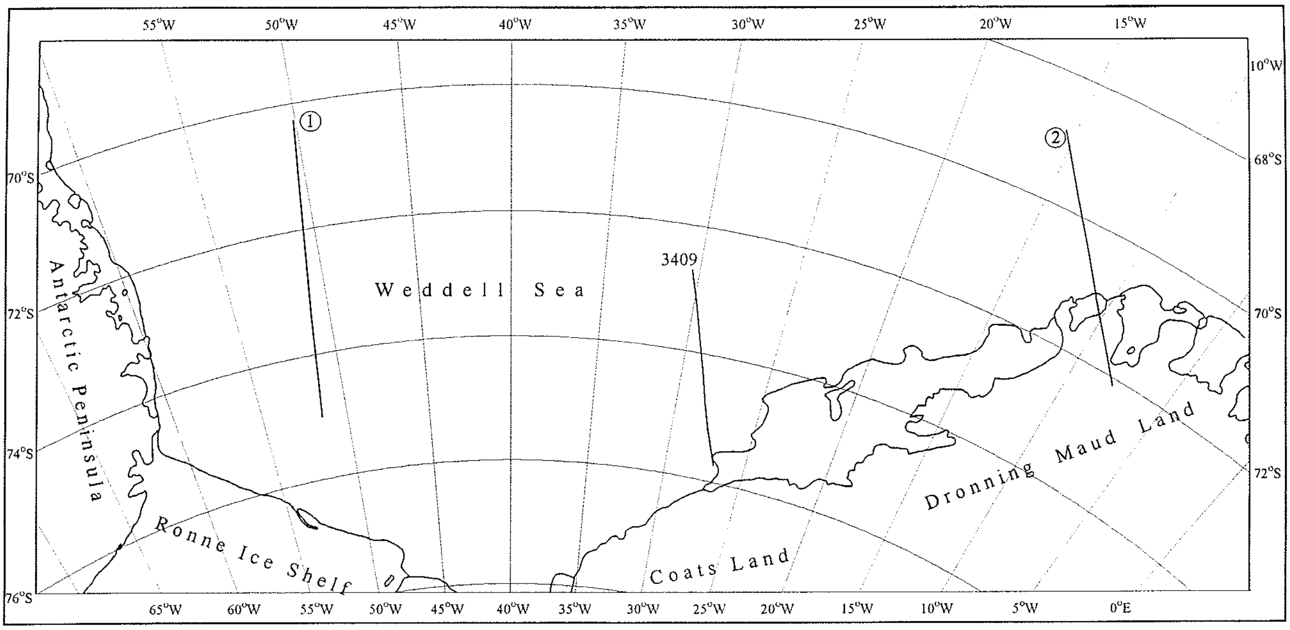

Fig. 5: Location map of aeromagnetic. Lines refer to modeled profiles in Figures 2 through 4.

Abb. 5: Lage der flugmagnetischen Linien, die den modellierten Profilen in Abbildungen 2 bis 4 entsprechen.

extends some 50 km seaward of the bathymetric shelf-slope break. Similar results are obtained for the model across the margin where the Orion Anomaly is found (Fig. 4). High magnetic susceptibilities (0.05-0.15 SI units) of the causative bodies in both models strongly suggest an origin by mafic magmatism during continental rifting. The anomalous thickness of the crust at the seaward end of both models excludes the possibility of a transition from continental to normal oceanic crust beneath the southern Weddell Sea margin. This is in agreement with a previous suggestion that was made by GRIKUROV et al. (1991) implying that the lithosphere of some oceanic basins in the southern high latitudes may have a continental pre-history rather than being purely produced by spreading.

The latter interpretation is supported by recent geological and geophysical investigations in the abyssal basin and the continental rise area of the Dumont d'Urville Sea (TANAHASHI et al. 1997, YUASA et al. 1997). In this area the deformed thick sedimentary sequences are interpreted to have been deposited in the pre-rift and rifting stage seen under thick postbreak-up sediments, together with several structural basement highs of different origin. These phenomena suggest that the wide area of the Dumont d'Urville Sea is underlain by a crust intermediate between oceanic and continental. Moreover, the mineral chemistry of the dredged peridotites from a seamount located within the magnetic quiet zone show fertile subcontinental characteristics (YUASA et al. 1997). The similarities between two remote margins clearly exist, which suggest that the continent-ocean transition is rather gradual and more complex than a simple boundary. We do not exclude the possibility that true oceanic crust in the Weddell Sea may be present only northward from the T-Anomaly.

CONCLUSIONS

In accordance with our interpretation crystalline basement of the HN type may also lie beneath the Ellsworth-Whitmore Mountains, the Ronne Ice Shelf up to 59 °W in the east and northward up to the ice-shelf break and southern Palmer Land. The Precambrian basement which outcrops in the Shackleton and Argentina Ranges most likely underlies the eastern Ronne Ice Shelf and Filchner Ice Shelf. The linear depressions in the surface of the magnetic basement are interpreted in this study as deeply buried rift structures initially developed under the WSE admittedly during Early Paleozoic time. Although the present knowledge is inadequate to draw any definite conclusions about the processes active along the southern Weddell Sea shelf and margin we attribute the circular-shaped geometry of the magnetic features outlined over the southern Weddell Sea shelf as being due to a rifted and/or downfanlted crustal block which approximately corresponds to the General Belgrano Bank and supposedly of Late Proterozoic - Early Paleozoic in age. The continuity of the Orion Anomaly suggests that it marks an important crustal boundary (or the zone of igneous material) and is fundamentally related to syn-rifting or an early post-rift period of the margin, while the results of our studies based on modeling of potential field data suggest that the transition from continental to normal oceanic crust beneath the southern Weddell Sea margin may be present only northward from the T-Anomaly.

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