Geodynamics of the West Antarctic Rift System (WARS) and its implications for the stability of the West Antarctic Ice Sheet

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Abstract
The West Antarctic Rift System will be studied along several traverses in an interdisciplinary aerogeophysical and ground-based geological survey in order to deduce its role for the stability and non-linear melting dynamics of the West Antarctic Ice Sheet (WAIS).The structural analysis may also serve as a model for the breakup of West Antarctica since the Late Mesozoic.

Rational
The West Antarctic Rift System (WARS) is an active rift. It is due to lithospheric thinning of the non-cratonic area of West Antarctica that consists of a phanerozoic series of mobile belts. It is associated with widespread bimodal volcanism of mainly Neogene age. A volume of > 1 Mio km³ of subglacial volcanics are estimated judged from aeromagnetic surveys.

The WARS is in large parts overlain by the West Antarctic Ice Sheet (WAIS) which is the largest marine ice sheet remaining after the last glacial maximum. Since it was recognized that the ice sheet is undergoing rapid and dramatic changes in selected regions international projects were initiated in order to investigate the sources of these changes. However, most international research projects are limited to the Ross Sea and adjacent basement outcrops. Only during the 1990s investigations of the subglacial geology were performed in restricted areas within the central WARS of the Subglacial Byrd Basin by the **West Antarctic Ice Sheet Airborne Gravimetry** Initiative, e. g. in the CASERTZ quadrangle as well as in the area of Ice Stream D draining into the Ross Ice Shelf. Additional information was gathered by initiatives like NASA WAIS that aims for the stability. The results of aerogeophysical surveys - that must be addressed as restricted with respect to the continental dimensions of the rift system – indicate that

(a) the sedimentary basin with extensional horst and graben structures extends well into the Subglacial Byrd Basin
(b) some horst structure shows sinuous geometry
(c) the basin is associated with active volcanism
(d) subglacial caldera structures indicate voluminous magmatic systems within upper crustal levels
(e) the southern boundary fault of WARS extends north of Whitmore Mts. towards Ellsworth Mts.

These initial data suggest that the elevated heat flow due to volcanic activity may well affect the configuration, stability and non-linear melting dynamics of the WAIS. The dynamics of the WAIS may thus not only depend on changes in global climate but also on lithospheric dynamics within the WARS. However, in contrast to this relevance, very little is known about the overall lithospheric structure and dynamics of the WARS. This is especially true for the

WARS where it extends through the remote area of Ellsworth Land into the Bellingshausen Sea.

Project Plan

A model is here proposed that contradicts with existing ones and needs to be tested by traverses across the WARS in Marie Byrd Land, in Ellsworth Land as well as in the shelf area of the Bellingshausen Sea.
The WARS shows the characteristics of a horse tail structure that is expressed as dextral strike slip fault system at its one end in Ellsworth Land and develops into the extensional pull apart basin of the Ross Sea embayment at the other end. No mantle plume is needed for generation of the associated alkaline magmas as they are generated due to decompressional melting of a secondarily enriched subcontinental lithospheric mantle.

We thus propose three interdisciplinary aerogeophysical traverses performed in sequential years that are accompanied by on-ground geological studies of the geometry of neotectonic structures, geochemical character and age of volcanism (in order to characterize the dynamic history of the rift as well as the subcontinental mantle source) as well as fissiontrack analyses (for the deduction of the thermochronology of exposed basement rocks within the rift as well as on its shoulders):
(1) Siple Isl. (or Shepard Isl.) - Executive Committee Range - Byrd Station - unnamed active volcano at 82°S/110°W - Whitmore Mts.

(2) Thurston Isl. - Jones Mt. – Ellsworth Mts.

(3a) Thurston Isl. - Jones Mt. – former US Eights Station – Hudson Mts. or
(3b) on the Shelf Ice from Thurston Isl. across Bellingshausen Sea towards Alexander Isl.

The focus of the project is a multi-disciplinary aerogeophysical survey that should include imaging of ice sheet surface and subglacial topography as well as the magnetic and gravity fields of the subglacial lithosphere. It must thus be performed by multi-instrumented aircrafts as operated by the Support Office for Aerogeophysical Research (SOAR) or the AWI Bremerhaven, Germany. As the profiles should be associated with on-ground geology studies support by a number of helicopters is required. Transport to and from the coast of West Antarctica at Amundsen or Bellinghausen Sea may need support by an Ice beaker in addition to Polarstern (?).

Ad (1) The lithospheric structure of a cross section of the Byrd Subglacial Basin is generally known by US studies in the 90s (Behrendt, Bell, Blankenship), thus younger data exist from this area than those from the early 1960s; the existing mapped area could be extended across the rift by the new traverse in order to define the structural patterns of the southern and northern boundary systems of the rift. The area from the coast into the Subglacial Bird Basin was recently mapped by radi-echo sounding (Vaughan et al. 2001).
Following the traverses from Byrd Station to Whitmore Mts. that were used by International Transantarctic Science Expedition (ITASE) may be of logistic help, although they focused on collecting data that allow to reconstruct changes in climate and chemistry of the atmosphere over the past 200 years.

Ad (2) The area was recently covered by radio-echo sounding showing a complex subglacial character (Vaughan et al. 2001). If only one traverse would be possible within the project, this or no. 3a would probably be the first one necessary. However, the area is remote and the accessibility poor.

Ad (3a) As far as we know this landbased profile was not covered by aerogeophysical surveys even in the late 50s or 60s. Extrapolations stop landward before the coast is reached. The radio-echo sounding survey by Vaughan et al. (2001) only partly touched this area.

Ad (3b) it may be more convenient to do the geophysical survey in the shelf area rather than on land; however, the interdisciplinary aspect by combination with on-ground geology cannot be realized. However, the profile would connect the project to the long-term research and development subplan of the Alfred Wegener Institute for Polar and Marine Research (AWI, Germany) "Tectonic-sedimentary Dynamics of the Southern Pacific and the Pacific-Antarctic Margin".

Supporting Institutions
Detlef Damaske, BGR, Germany (IPY projects 10, 56)
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Rupert Sutherland, GNS Lower Hutt, New Zealand (IPY project 83; ANDRILL Principal Investigator, NZ Project 2: Tectonic evolution of the West Antarctic Rift System)
Slawek Tulaczyk, UCSC Santa Cruz, USA (member of WAIS research group, IPY projects 35, 37 FASTDRILL)

Interrelations with other IPY proposals
- Close regional and thematic links are given with IPY project no. 37
- Regional neighbourship and methodical links are given to IPY project 80