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**TECTONICS OF THE SOUTHERN ANDEAN
INTRA-ARC ZONE (38° – 42°S)**

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ABSTRACT

This study targets endogene and exogene processes operating at the transition of the high-relief Central Andes to the low-relief Patagonian Andes. The climatic and stationary tectonic setting of the study area including the Southern Andean intra-arc zone/Main Cordillera between latitudes 38° and 42°S provides insights into ca. 380 Ma of subduction-related magmatic and tectonic processes exhumed at different crustal levels. Analysis of multimethod and multiscale datasets aims to complete the knowledge about the tectonic evolution of the Southern Andean intra-arc zone and to improve the understanding of the dynamics of active margin systems. More specifically, remote sensing data (Landsat TM imagery and air photos) in combination with digital geologic and hydrologic maps and digital elevation models were joint to a “virtual Southern Andes” GIS (Geographic Information System)-database, analyzed geomorphometrically and interpreted morphotectonically. Structural mapping, fault kinematic analysis, petrologic investigations, and isotope-geochronology were used to form a base for conceptual tectonic models. Kinematic modeling gave for the first time reasonable estimates of Neogene amounts and rates of intra-arc deformation.

The topography of the Southern Andean intra-arc zone/Main Cordillera basically reflects the southward increasing efficiency of Neogene erosion on the western, windward side of the orogen. More specifically, a southward decreasing elevation concurrent with an increasing incision and a change from V-shaped valleys to U-shaped valleys are consistent with a change from dominantly fluvial erosion in the north to dominantly glacial erosion in the south. Accordingly, the level of exhumation of the magmatic arc basement increases southward from shallow to mid-crustal levels. Erosional unloading, heavily partitioned spatially into the south of the study area and temporarily into the glacials, accounts for at least one third of the observed differential rock uplift and exhumation since the Miocene.

The tectonic history of the Southern Andean intra-arc zone/Main Cordillera includes longlasting (tens to hundreds of millions of years) periods of extension and basin formation during the Mesozoic and Oligocene - Miocene alternating with relatively short (several million years) intervals of transpression and mountain building/exhumation during the mid-Cretaceous and Late Miocene. Amounts of cross-arc shortening are one order of magnitude smaller than in the Central Andes consistent with models of orocline formation by differential shortening. The youngest increment of intra-arc deformation in the Southern Andes is represented by the Liquiñe-Ofqui Fault Zone (LOFZ) which has been active as a brittle SC-like dextral shear zone decoupling a fore-arc sliver. A kinematic model suggests that the LOFZ has accommodated ca. 84 km (+66, -28) of dextral shear since the Pliocene. This displacement is consistent with offset of regional geological markers, vertical axis rotations, and the space provided in the fore-arc by Neogene Central Andean plateau formation. The resulting displacement rate suggests that about half of the margin-parallel component of oblique convergence between the Nazca and South American plates has been partitioned into the intra-arc zone. The remaining half of margin-parallel slip has been most probably accommodated by oblique thrusting in the accretionary wedge and to a minor amount eventually by internal deformation of the fore-arc.

There is no clear temporal relationship between plate kinematic parameters and deformation of the overriding plate. This implies that active margin deformation is controlled primarily by other factors than plate kinematics. The observation that increments of transpression follow increments of crustal extension and are late-synmagmatic with respect to emplacement of arc-granitoids suggests that subduction orogeny is triggered by magmatic weakening and crustal thinning. Initiation of the LOFZ was concurrent with collision of the Chile Ridge at the southern end of the Southern Volcanic Zone of the Andes suggesting that, under favorable mechanical conditions, extensional forces associated with subduction of an active spreading center have a primary control on fore-arc sliver formation.

ZUSAMMENFASSUNG

Diese Studie untersucht endogene und exogene Prozesse am Übergang der zentralen zu den patagonischen Anden. Der klimatische und tektonische Rahmen, in dem sich das Arbeitsgebiet in der südandinen Vulkanzone/Hauptkordillere zwischen 38° und 42° südlicher Breite befindet, ermöglicht Einblicke in ca. 380 Millionen Jahre subduktionsbezogener magmatischer und tektonischer Prozesse in verschiedenen Krustenstockwerken. Die Analyse multimethodischer und multiskaliger Datensätze zielt darauf ab, das Wissen über die tektonische Entwicklung der südandinen Vulkanzone zu vervollständigen und das geodynamische Verständnis aktiver Kontinentränder zu verbessern. Im Einzelnen wurden fernerkundliche Daten (Landsat TM und Luftbilder) in Kombination mit digitalen Geländemodellen geomorphometrisch analysiert und morphotektonisch interpretiert. Strukturgeologische Kartierung, störungskinematische Analyse, petrologische und isopen-geochronologische Untersuchungen dienten als Basis konzeptueller tektonischer Modelle. Kinematische Modellierungen ergaben erstmals zuverlässige Abschätzungen Neogener Deformationsbeträge und -raten.

Die Topographie der südandinen Vulkanzone/Hauptkordillere reflektiert prinzipiell die nach Süden hin zunehmende Effizienz Neogener Erosion auf der westlichen, windzugewandten Flanke des Orogens. Die nach Süden hin abnehmende Höhe zusammen mit der zunehmenden Eingeschnittenheit und dem Übergang von V- zu U-Tälern sind konsistent mit einem Übergang von fluvialer zu glazialer Erosion. Dementsprechend steigt die Exhumierung des magmatischen Bogens nach Süden hin von flachkrustal zu mittelkrustal an. Entlastung durch Erosion, vor allem während der Eiszeiten und im Süden des Arbeitsgebietes, hatte zu mindestens einem Drittel Anteil an der beobachteten differentiellen Hebung und Exhumierung seit dem Miozän.

Die tektonische Geschichte der südandinen Vulkanzone/Hauptkordillere beinhaltet lang anhaltende Perioden (Zehner bis Hunderte Millionen Jahre) von Extension und Beckenbildung während des Mesozoikums und im Oligozän – Miozän abwechselnd mit relativ kurzen (wenige Millionen Jahre) Intervallen von Transpression und Gebirgsbildung/Exhumierung während der mittleren Kreide und im späten Miozän. Die Beträge Vulkanzonen-orthogonaler Verkürzung sind eine Größenordnung kleiner als in den Zentralanden konsistent mit Modellen der Oroklinenbildung durch differentielle Verkürzung. Das jüngste Inkrement der Deformation im Bereich der südandinen Vulkanzone wird durch die Liquiñe-Ofqui Störungszone (LOFZ) repräsentiert, die als spröde SC-ähnliche dextrale Scherzone aktiv gewesen ist und zur Abkopplung eines *fore-arc slivers* geführt hat. Ein kinematisches Modell zeigt, dass die LOFZ ca. 84 km (+66, -28) dextrale Scherung seit dem Pliozän aufgenommen hat. Dieser Versatz ist konsistent mit dem Versatz regionalgeologischer Marker, Blockrotationen und dem Platz der durch die Neogene zentralandine Plateaubildung zur Verfügung steht. Die resultierende Versatzrate deutet an, dass ca. die Hälfte der plattenrandparallelen Komponente der schiefen Konvergenz zwischen der Nazca und der südamerikanischen Platte im Bereich der Vulkanzone aufgenommen worden ist. Der verbleibende Anteil wurde vermutlich durch schiefe Akkretion und interne Deformation des *fore-arcs* aufgenommen.

Es gibt keinen klaren zeitlichen Zusammenhang zwischen plattenkinematischen Parametern und der Deformation der Oberplatte, was den Schluss nahe legt, dass die Deformation am aktiven Kontinentalrand durch andere Faktoren kontrolliert wird. Im Einzelnen folgen transpressive Inkremente auf Inkremente krustaler Ausdünnung und sind spätmagmatisch im Bezug auf die Platznahme von Granitoiden im magmatischen Bogen, was die Folgerung zulässt, dass magmatische Schwächung und krustale Ausdünnung Auslösefaktoren der Subduktionsorogenese sind. Die Entstehung der LOFZ erfolgte zeitgleich mit der Kollision des Chile Rückens am südlichen Ende der südandinen Vulkanzone, was den Schluss nahe legt, dass unter geeigneten mechanischen Bedingungen Extensionkräfte im Zusammenhang mit der Subduktion eines aktiven Spreizungszentrums eine Hauptursache der *fore-arc sliver*-Entstehung ist.

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