The Swiss geotraverse from Basel to Chiasso

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Swiss National Committee for the International Geodynamics Project
Working Group 13: Geotraverse Basel-Chiasso

The Swiss Geotraverse from Basel to Chiasso

Report by *L. Rybach**)

1. ORGANISATION

In 1974 the Swiss National Committee for the International Geodynamics Project established, on Proposal by Prof. E. Niggli (Bern), a Working Group "Geotraverse Basel-Chiasso". The primary aim of this Working Group was to initiate, concentrate and coordinate multi-disciplinary research on the Geotraverse area in order to clarify its structure, dynamic history and present dynamics. Since the Geotraverse passes through numerous complex geologic-tectonic units including the Alps, it represents a unique opportunity to contribute fundamentally to the understanding of the geodynamics of prominent geotectonic features, and thus to the International Geodynamics Project in general.

Working Group members are: J. Ansorge (Zurich), H.U. Bambauer (Münster/FRG), D. Bernoulli (Basel), P. Bitterli (Basel), U. P. Büchi (Forch), R. Egloff (Zurich), P. Finckh (Zurich), G. Fischer (Neuchâtel), W. Fischer (Zurich), M. Frey (Basel), H. Friedrichsen (Tübingen/FRG), A. Gansser (Küsnacht), E. Gubler (Bern), St. Hafner (Marburg/FRG), J. Hansen (Bellinzona), L. Hauber (Basel), S. Hoernes (Tübingen/FRG), E. Huber (Bern), M. Huber (Zurich), E. Jäger (Bern), H.-G. Kahle (Zurich), E. Kissling (Zurich), E. Klingelé (Zurich), V. Köppel (Zurich), T.P. Labhart (Bern), H. Laubscher (Basel), W. Lowrie (Zurich), A.G. Milnes (Zurich), J. Mullis (Fribourg), W. Nabholz (Bern), J. Neugebauer (Frankfurt a.M./FRG), St. Mueller (Zurich), E. Niggli (Bern), R. Oberhänsli (Bern), N. Pavoni (Zurich), J. G. Ramsay (Zurich), L. Rybach (Zurich,) J. P. Schaer (Neuchâtel), M. Schürer (Bern), H. Schwendener (Zurich), C. Simpson (Zurich), G. Voll (Bonn/FRG), J. J. Wagner (Genève), E. Wenk (Basel) and D. Werner (Zurich).

The first presentation of research activities and results from the Geotraverse area was given at a special Symposium which was jointly organized by the Swiss Geological Society and by the Swiss Mineralogical and Petrographical Society. The "Symposium Geotraverse Basel-Chiasso" took place in Geneva

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on October 9, 1976. 22 papers have been given; most of them are published in Schweiz. Min. Petr. Mitt. *56*, pp. 555–707: W. Oberholzer & L. Rybach (eds.): Symposium "Geotraverse Basel–Chiasso", *Inter-Union Commission on Geodynamics Scientific Report No. 37.*

The final results of the Working Group will be presented at the Symposium "Alpine Geotraverses with Special Reference to the Basel-Chiasso Profile" on October 4–5, 1979 in Lausanne. The Symposium Proceedings will be published in Eclogae geol. Helv. 73/2 (1980).

2. LOCATION OF THE TRAVERSE, GEOLOGY

The line Basel–Chiasso indicates the general axis of the traverse (total length: 220 km) which cross-sects, more or less perpendicularly to the general strike direction, the main geologic units of Switzerland: the Rhine Graben, the Plateau Jura and Folded Jura Mountains, the Molasse Basin, the Helvetic nappes, the Central Massifs with their autochthonous cover, the Penninic units (=deepest exposed units) and, south of the Insubric Line, the crystalline and sedimentary units of the Southern Alps (Fig. 1). The geologic section along the Geotraverse Basel–Chiasso (Büchi & Trümpy, 1976) is shown in the top part of Fig. 2 (no vertical exaggeration). Though many fascinating details of structural geology are lost on this reduced scale the overriding of the Molassed Basin (unit no. 1) by the Helvetic nappes (unit no. 3) is evident. The other units are: Flysch sediments (2), sediments of the Southern Alps (4) and of the Penninic nappes (5), Jurassic and autochthonous sediments (6), crystalline basement incl. the Central massifs (7), intensively deformed crystalline units incl. those in the Southern Alps (8), ultrabasites, Ivrea Zone (9) and Paläozoic volcanites (10).

3. METAMORPHISM AND DEFORMATION

The main metamorphic event in the section of the Swiss Geotraverse Basel–Chiasso has been the one in the Middle Tertiary (the so-called Lepontine phase), reaching amphibolite grade. The early-Alpine phase (Lower Cretaceous) which is well preserved in the Western Alps in low T/high p facies (Frey et al., 1974) has been almost completely overprinted by the Lepontine metamorphism. The metamorphic grade increases from N to S in the section of the Geotraverse as documented by mineral zone boundaries and isogrades (Frey et al., 1976); geothermal gradients calculated from estimated p-T conditions appear to decrease from 45°/km to 25°/km from low to high metamorphic grade.

Increasing degree of Alpine deformation from N to S is also evident in the

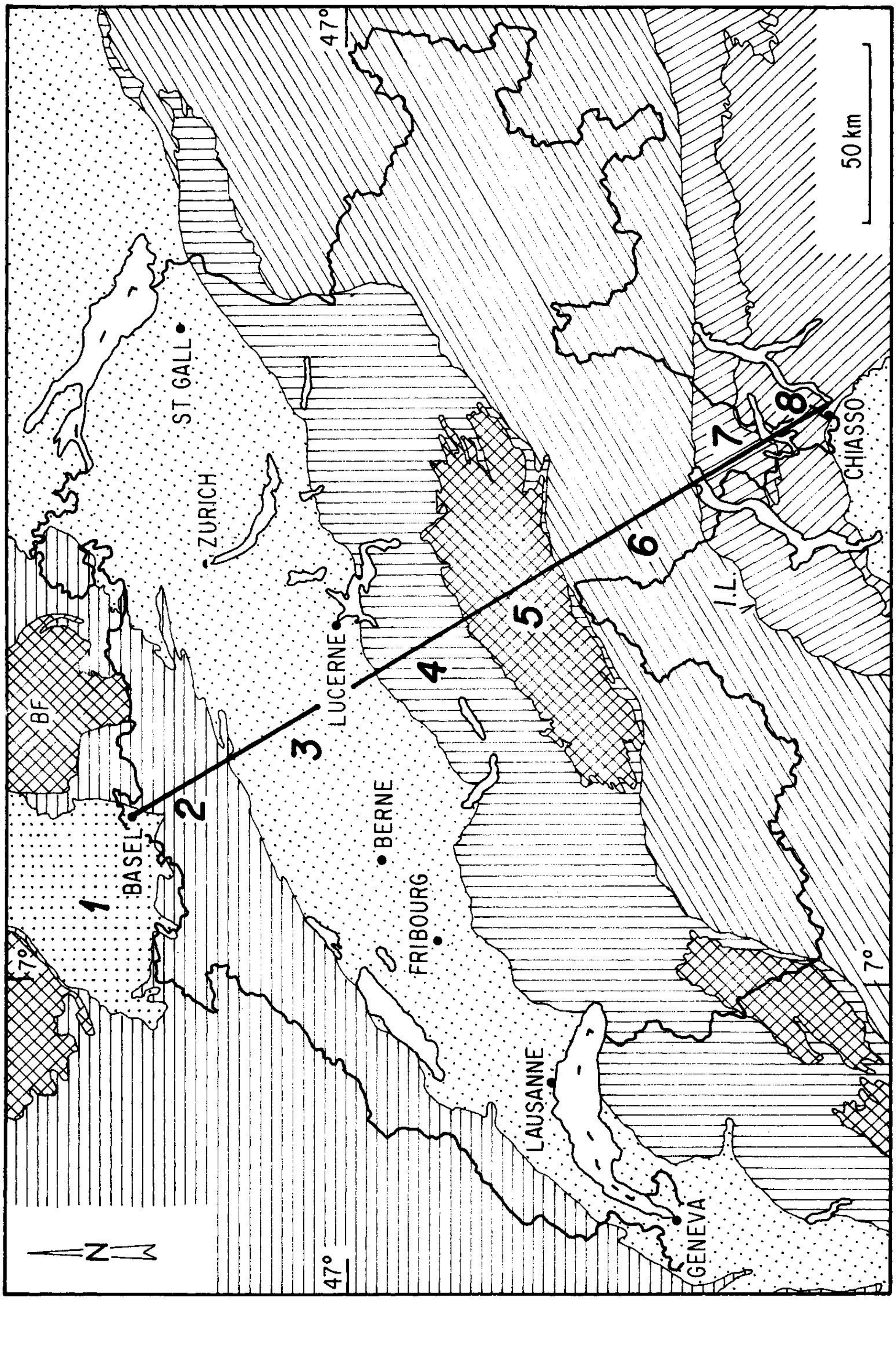
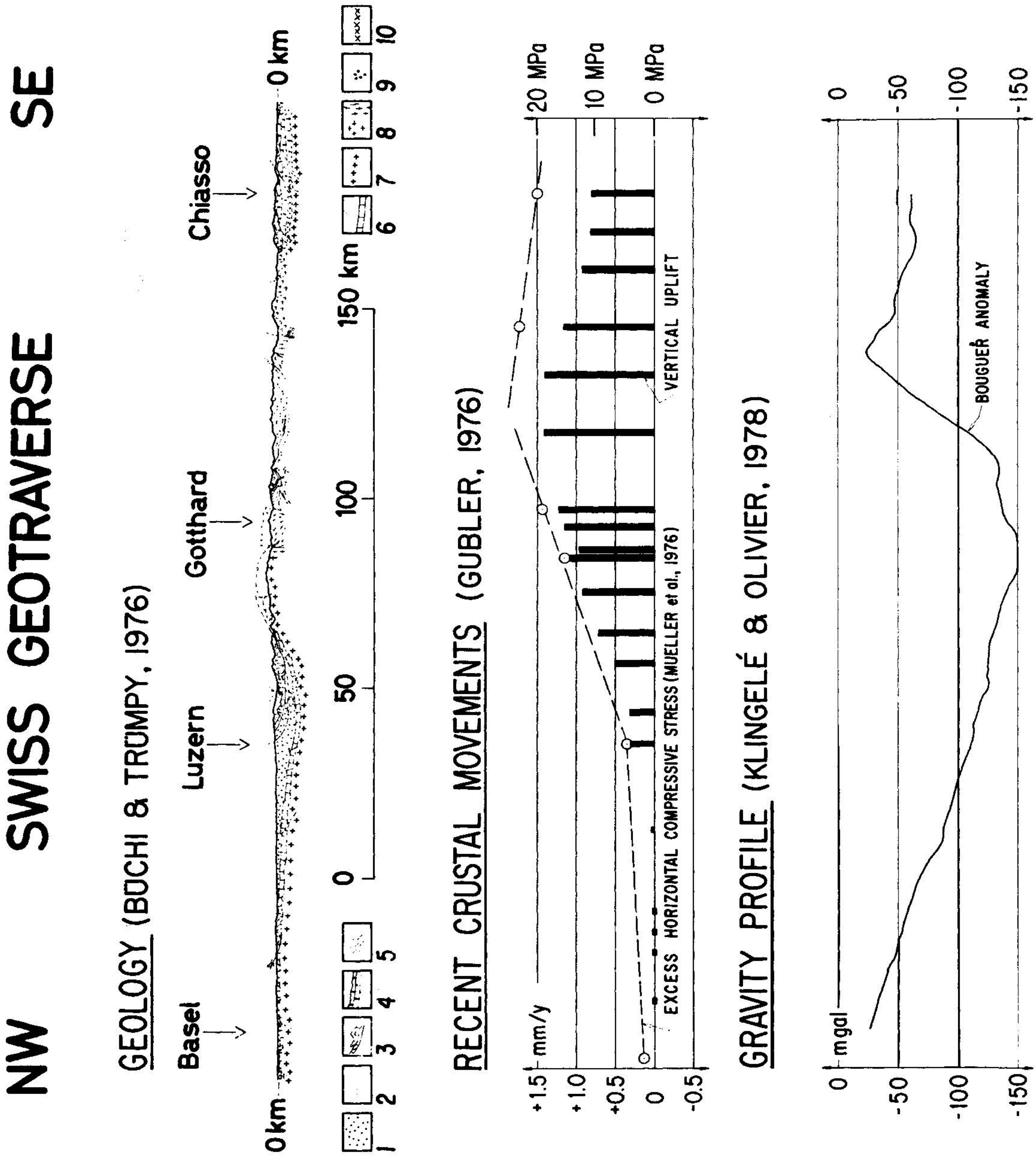


Fig. 1 The profile trace of the Swiss Geotraverse Basel-Chiasso crosses the main geologic-tectonic units (1: Rhine Graben, 2: Jura Mountains, 3: Molasse Basin, 4: Helvetic nappes, 5: Central Massifs with autochthonous cover, 6: Penninic units, 7: crystalline and 8: sedimentary units of the Southern Alps) more or less perpendicularly to the general strike direction. I.L.: Insubric Line.



NW SWISS GEOTRAVERSE SE
GEOLOGY (BÜCHI & TRÜMPY, 1976)
Basel
Luzern
Gotthard
Chiasso
0 km
0 km
0
50
100
150 km
1
2
3
4
5
6
7
8
9
10
RECENT CRUSTAL MOVEMENTS (GUBLER, 1976)
mm/y
+1.5
+1.0
+0.5
0
-0.5
20 MPa
10 MPa
0 MPa
VERTICAL UPLIFT
EXCESS HORIZONTAL COMPRESSIVE STRESS (MUELLER et al., 1976)
GRAVITY PROFILE (KLINGELÉ & OLIVIER, 1978)
mgal
0
-50
-100
-150
BOUGUER ANOMALY

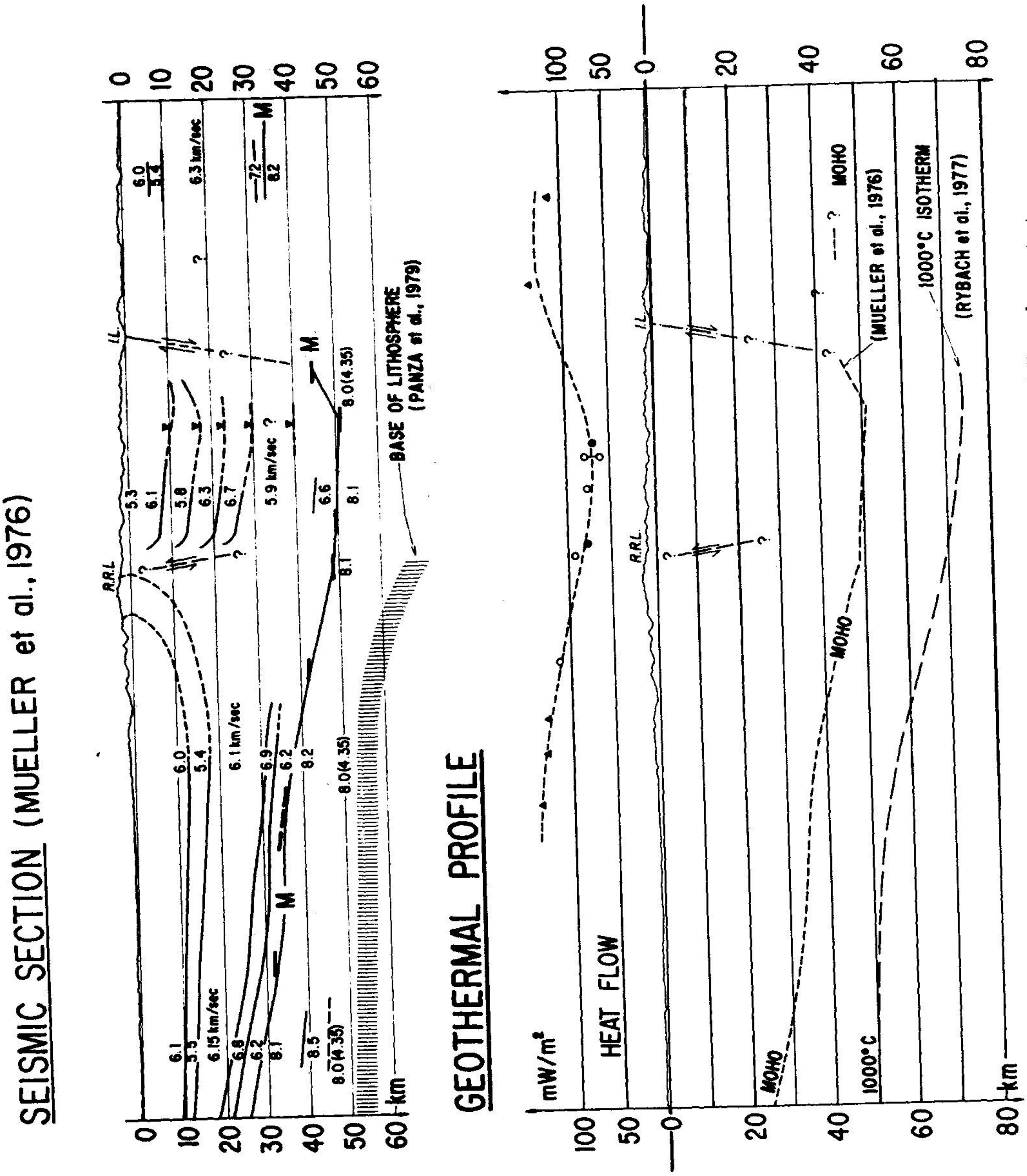


Fig. 2 Synoptic representation of the Swiss Geotraverse. For detailed discussion see text.

section of the Geotraverse. Besides megascopically visible features, microscopic studies revealed effects reaching from plastic deformation of quartz, kink bands in micas to recrystallisation of quartz, feldspars and micas in the southern part of the traverse (VOLL, 1976). The Insubric Line marks a pronounced change in metamorphic grade and degree of deformation.

4. CRUSTAL MOVEMENTS AND GRAVITY

The direction of the Swiss Geotraverse corresponds, with respect to the regional stress field, to the direction of maximum horizontal compression in the upper crust (N 160°E), as revealed by earthquake fault-plane solutions and in-situ stress determinations (PAVONI. 1976). The traverse also cross-sects, roughly in its central part, a zone characterized by strong recent vertical uplift rates (up to 1.5 mm/year; GUBLER, 1976) and negative Bouguer and isostatic anomalies (−160 and −20 mgal, respectively; KAHLE et al., 1976). The uplift rates increase from the northern border of the Alps towards the Lepontine area (in accordance with the excess horizontal compressive stress in the upper crust which reaches there a maximum of about 20 MPa; MUELLER et al., 1976) and decrease again towards the south (Fig. 2). No significant change in the uplift pattern can be seen in crossing the Insubric line; the pattern may change, however, within relatively short time periods (KOBOLD, 1977). The crustal uplift may be the result of isostatic rebound as well as of an upbulging due to the compression caused by the push of the African plate.

5. CRUSTAL STRUCTURE (SEISMIC SECTION)

Two layers of velocity inversion have been found by refraction profiling in the northern part of the traverse showing especially low V_p velocities in the lower crust (6.0 km/sec); the upper zone of inversion seems to emerge at the surface in the Aar massif (MÜLLER et al., 1976). The crust-mantle boundary is highly asymmetric (the maximum crustal thickness of 50 km coincides with the zone of maximum vertical uplift). The Gotthard–Lepontine section may incorporate subducted parts of crustal blocks ("Tavetscher Zwischenmassiv"). The Insubric Line appears to cut through the entire crust; the available data indicate normal crustal thickness south of the Insubric Line with higher average seismic velocities (Fig. 2). The lithosphere-asthenosphere system in Europe is characterized by pronounced changes of the lithosphere thickness over relatively short distances (PANZA et al., 1979). In the southern part of the Geotraverse Basel–Chiasso the lithosphere-asthenosphere boundary exhibits a pronounced dip towards the south.

6. HEAT FLOW

The heat flow pattern in the section of the traverse is characterized by low heat flow values in the Central Alps, flanked by higher heat flow zones (data in Fig. 2 from RYBACH & FINCKH, 1979); triangles: determinations in lake bottom sediments; dots; measurements in drillhole/shaft). A similar pattern has been found in the Eastern Alps by R. HÄNEL (personal communication). The temperature field shows correspondingly depressed isotherms in the Central Alps; the 700 °C isotherm coincides roughly with the Moho relief. Surprisingly the values of "paleo-heat flow" (open circles), estimated on the basis of p/T data of metamorphic mineral reactions reported by FREY et al. (1976), fit well into the heat flow curve (= heat flow as measured today).

Model calculations have been performed to consider the uplift/cooling history of the Lepontine area (WERNER et al., 1976). In order to fit the geochronological data the uplift rates must have been temporarily much higher in the period of 25 to 18 million years b.p. (up to 4 mm/year) than they are today. A quiescent period during the Pliocene is also evident from these calculations (cf. p. 144 of this volume). The thermal "low" in the Central Alps can be interpreted as the remainder of a thermal disturbance caused by underthrusting/subduction (for analogy see e.g. the Sierra Nevada/USA).

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