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Autor: Pavoni, N.

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Swiss National Committee for the International Geodynamics Project
Working Group 1: Recent Crustal Movements

Investigation of Recent Crustal Movements in Switzerland

Report by *N. Pavoni**)

1. Introduction

The Working Group was established in June 1971. It consists of 20 scientists, geologists, geodesists and geophysicists, actively interested in the study of recent crustal movements in Switzerland. The activities of the group include geological-geomorphological, geodetic and microearthquake investigations. The close cooperation and coordination of efforts of earth scientists of these different branches of research proved of great value. A first and major step towards a systematic study of recent crustal movements has been realized. During the same time close contacts with neighbouring countries regarding the investigation of RCM could be established. Apart from the research work, several members of the group were engaged in the organisation of the "Fifth International Symposium on Recent Crustal Movements" held in Zurich from August 26–31, 1974. The work of the group was generously supported by the Topographical Survey of Switzerland, the Swiss Federal Institute of Technology and several Universities and the Swiss National Fund. The collaboration and aid of these institutions is gratefully acknowledged.

2. Geological-geomorphological investigations

2.1 SELECTION OF LOCAL TEST AREAS

The first task of the group was to evaluate and select possible test areas for a systematic study of recent crustal movements. For this purpose, a questionnaire was distributed in February 1971 among geologists of Switzerland. In addition to the inquiry photogeological investigations combined with field reconnaissance were performed by geologists of the group in the following areas:

Vorderrhein – Tavetsch – Oberalppass
Val Canaria – Val Piora – Valle del Lucomagno
Malojapass area – Upper Engadine – Lower Engadine
Simplon area – Nanztal – Gebidem

*) Institute of Geophysics, ETH-Hönggerberg, CH-8093 Zurich (Switzerland)

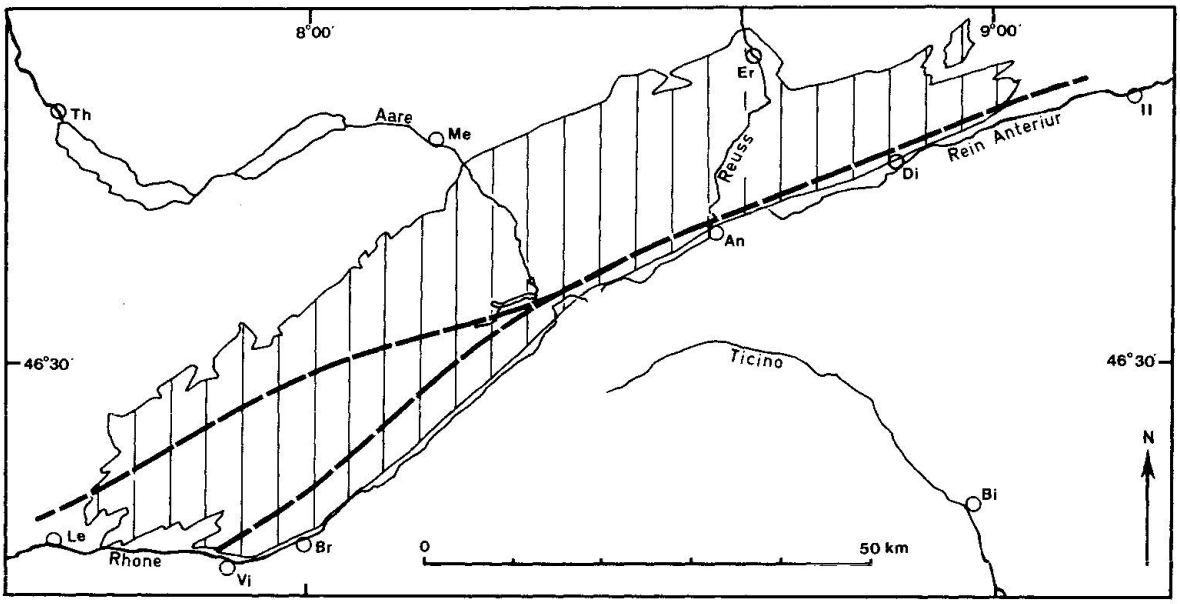


Fig. 1 Sketch map showing the extent of the Rhine-Rhone zone (dashed). An Andermatt, Bi Biasca, Br Brig, Di Disentis, Er Erstfeld, Il Ilanz, Le Leuk, Me Meiringen, Th Thun, Vi Visp. Vertical hatching: crystalline rocks of the Aar massif.

2.2 RHINE - RHONE ZONE

During 1975–1979 a systematic and comprehensive geological-geomorphological study of this major tectonic zone (JÄCKLI, 1951; ECKARDT, 1957, 1974) has been performed by geologists of the group (Fig. 1). The study was supported by a grant of the Swiss National Fund. The scientific report will be completed in March 1980.

2.3 WILDHORN ZONE

A reconnaissance photogeologic and field study was performed in the Wildhorn zone and in the Sanetschpass area (PAVONI, 1976, 1979) in order to detect young fault structures in this seismically active area (Fig. 5).

3. Geodetic investigations

3.1 STUDY OF REGIONAL VERTICAL MOVEMENTS

During 1971–1979 the following lines of the federal net of precise leveling were re-observed by the Topographical Survey of Switzerland:

Basel - Gotthard - Chiasso (1967–1971)
Sargans - Chur - Oberalp - Andermatt (1972/73)
Disentis - Lucomagno (1973)
Hospental - Oberwald - Brig - Visp (1975)
Martigny - Col de la Forclaz - Le Châtelard (1975)

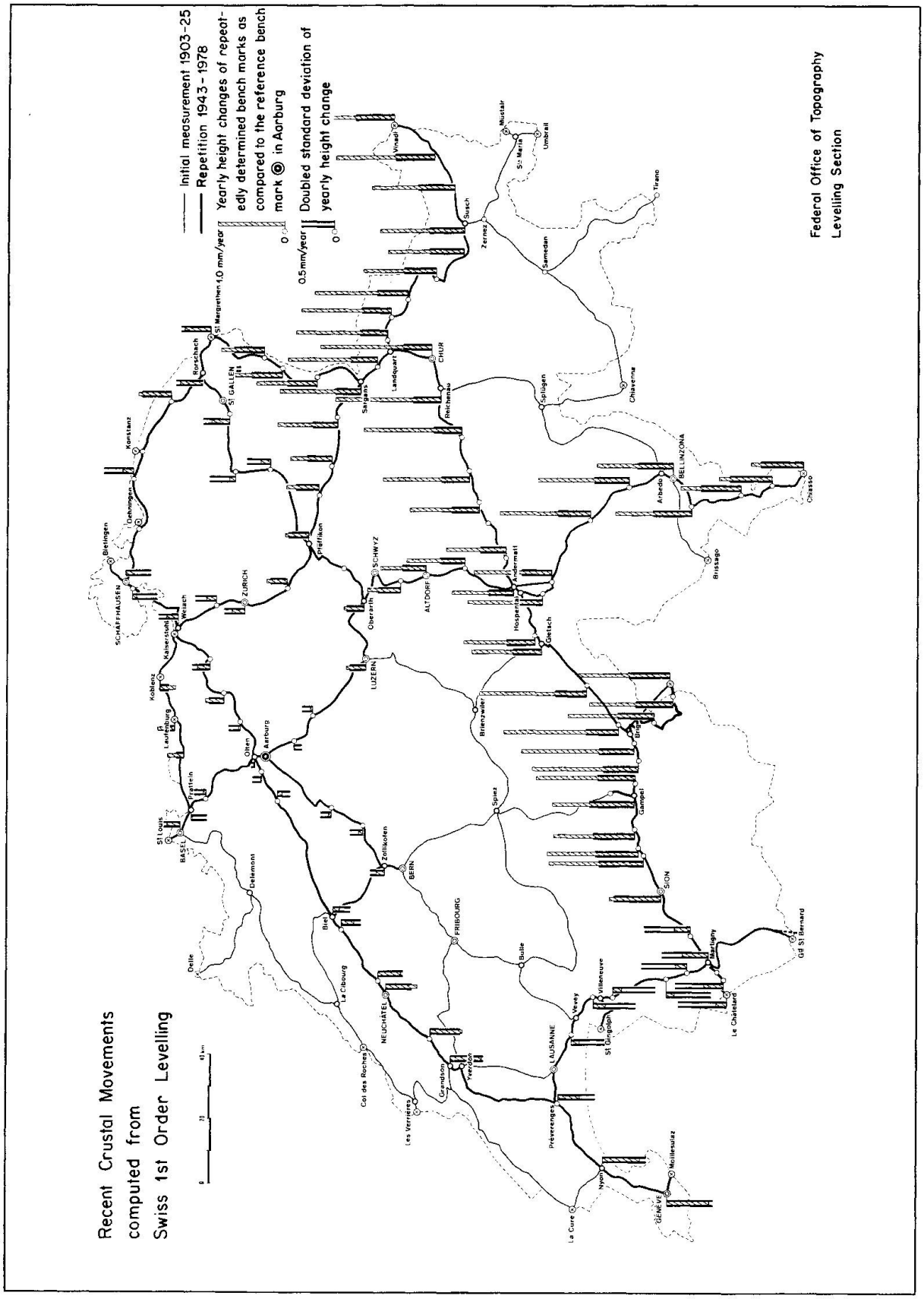
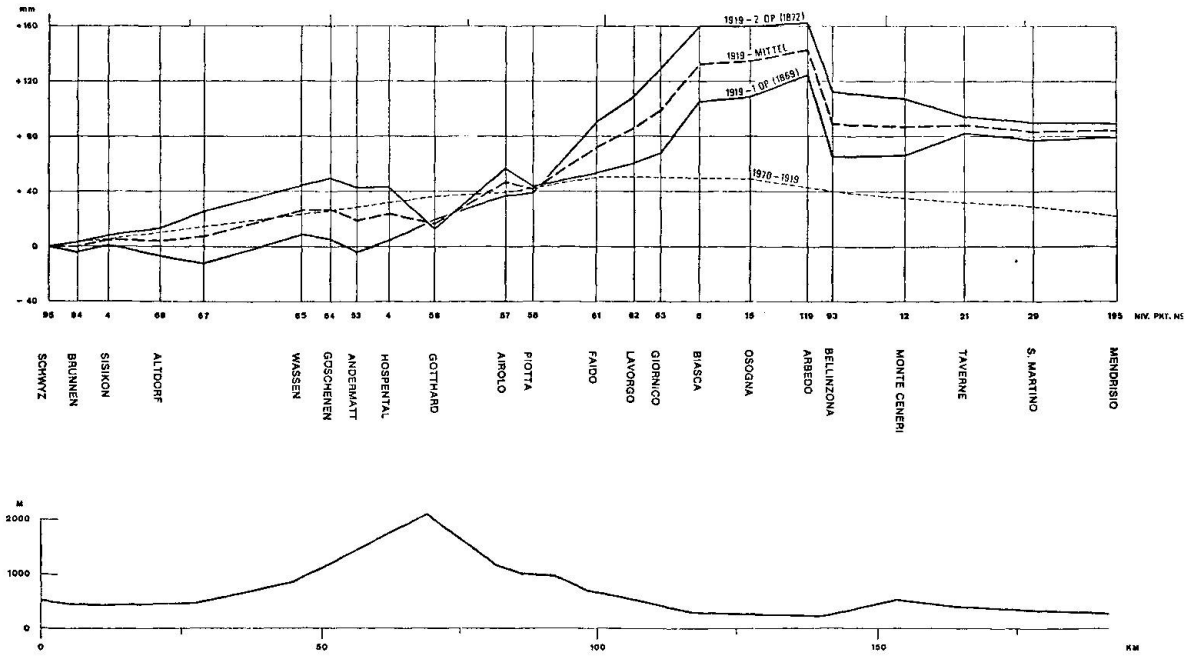


Fig. 2 Rates of vertical crustal movements in Switzerland derived from re-observed precise levelling lines 1903–1925 and 1943–1979. After GUBLER, 1979.

Landquart - Davos - Susch - Martina (1976/77)
Gotthard road tunnel (1976 and 1979/80)
Gotthard railway tunnel (1977) (Fig. 4)
Kaiserstuhl - Koblenz - Brugg (1977)
Simplonpass: Brig - Iselle (1977)
Koblenz - Pratteln (Basel) (1978)
Martigny - Grand St. Bernard (1978)
Simplon railway tunnel (1979)
Bellinzona - Soazza (1979)

The average time span between old (1907–1919) and new (1943–1979) surveys is 50 years. First results on observed uplift along the N-S profile Basel-Gotthard-Chiasso were published by JEANRICHARD (1972, 1973). Because of the irregular time intervals between new and old levellings it proved advantageous to calculate rates of vertical movements relative to a reference group of fixpoints near Olten/Aarburg (PAVONI, 1975; GUBLER, 1976). Fig. 2 illustrates the latest state of knowledge according to GUBLER (1979). About two thirds of the federal leveling net (3000 km length of lines) have been re-measured. The results show maximum rates of uplift relative to Aarburg of 1.7 mm per year near Chur, Grisons, and Brig, Valais, and 1.4 mm per year near Biasca, Lepontine Alps. The maximum observed uplift rates correspond well with the large negative Bouguer anomaly observed in the central Grisons (−180 mgl) and near Brig (−170 mgl). They are in good agreement with mean denudation rates of 0.3 to 0.6 mm per year as determined for several river systems in the Swiss Alps. They

Fig. 3 Uplift along the N-S profile Schwyz-Gotthard-Mendrisio calculated from three precise levellings 1869/72, 1919 and 1970. After KOBOLD, 1977.



are also in good agreement with estimated upheaval rates of the crystalline underground based on geochronological and heat flow data (JÄCKLI, 1958; CLARK, S.P. & E. JAEGER, 1969; SCHAER & JEANRICHARD, 1974; WERNER et al., 1976). In a special study KOBOLD (1977) compared the data of the "Nivellement de précision" performed 1865–1887 with the later 1919 and 1970 surveys. Along the N-S profile Schwyz–Mendrisio and also along the section Sargans–Chur–Oberalp–Andermatt the calculated uplift rates for the period 1870–1919 are in good agreement with the uplift rates calculated for the period 1919–1970 (Fig. 3) and confirm the latter.

3.2 LOCAL GEODETIC TEST POLYGONS TO DETERMINE ACTIVE FAULT MOVEMENTS

Four test sites (JEANRICHARD, 1974; PAVONI, 1975) were installed:

3.2.1 Schöllenen, near Andermatt

The site is situated tectonically on the southern border of the Aar massif along the Rhine-Rhone zone.

3.2.2 Gütsch–Stöckli–Lutersee, Oberalppass

The test area is situated in the Rhine-Rhone zone 4 km E of the Schöllenen site at a much higher altitude of 2400 m. 6 profiles were installed 1976 and re-observed 1978 (FISCHER, 1978).

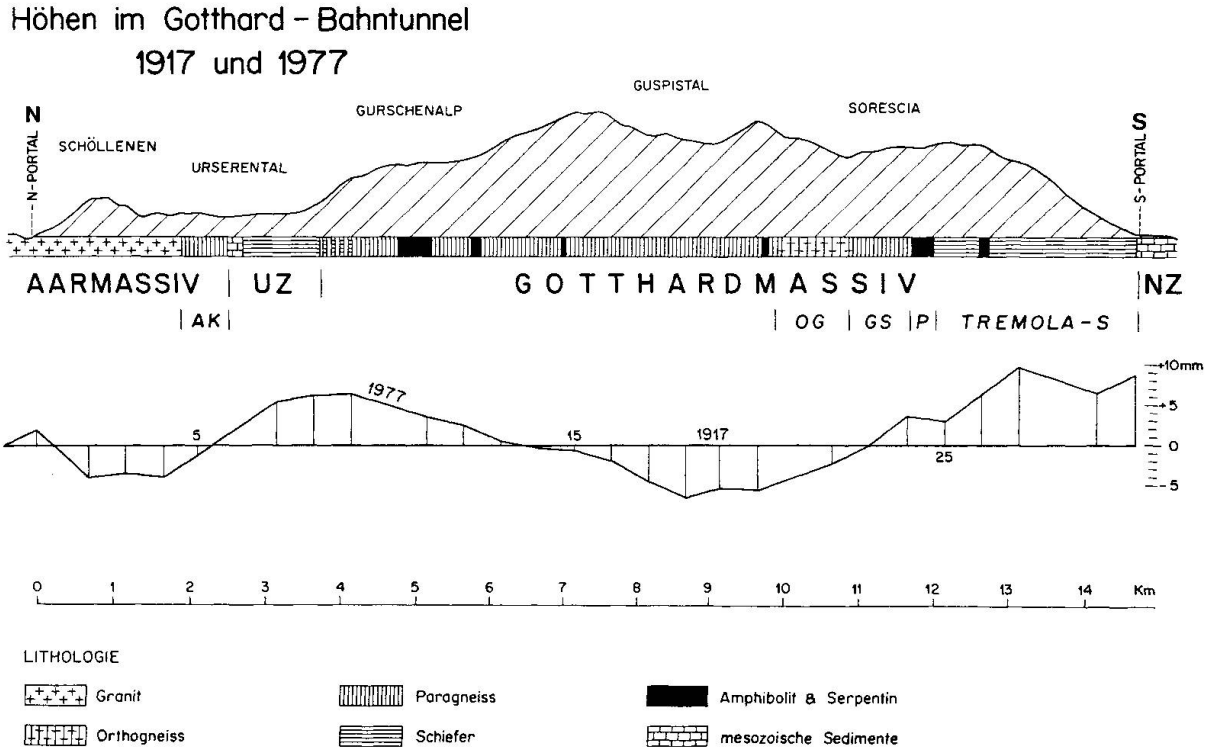


Fig. 4 Gotthard railway tunnel. Height changes of the bench marks between 1917 and 1977 (lower profile), and simplified geological profile. After FUNK & GUBLER, 1979.

3.2.3 Le Pont, Jura Mountains

Two quadrilaterals have been installed at Le Pont on the Pontarlier strike-slip fault in order to determine horizontal movements and strain along and near the fault. The Pontarlier fault is one of the major strike-slip faults of the Jura Mountains. Seismic activity is associated with this fault.

3.2.4 Basel

At Basel two precise leveling traverses in E-W direction across the eastern boundary fault zone of the Upper Rhine graben were installed and measured in 1973. Each line is about 6 km long.

4. Seismological investigations to determine local tectonic activity

4.1 NORTHEASTERN SWITZERLAND

Microearthquake studies of one or two months duration were carried out in northeastern Switzerland, in the Kanton Thurgau, Kanton Appenzell and near Chur, Grisons. No special local seismic activity was found during the periods of measurement.

4.2 CENTRAL VALAIS

Several field surveys during 1974–1977 using five portable seismic stations revealed a more or less continuous local seismic activity in the Sanetschpass–Wildhorn–Rawilpass region (PAVONI, 1976, 1979). The Wildhorn zone is of special interest because it is the site of the strong 1946 Valais earthquake. Young fault movements are observed in this region (Fig. 5).

4.3 SEISMICALLY ACTIVE FAULT ZONES

The following fault zones may be regarded as seismically active (PAVONI, 1977, 1979):

- The Lake of Constance fault zone trending N60° W with dextral lateral slip.
- N–S trending strike-slips faults of the Jura Mountains. There are strong indications that recent continuing tectonic activity is associated with a series of N–S to NW–SE trending strike-slip faults in the basements and in the sedimentary cover of the Jura Mountains, e.g. Vuache strike-slip fault zone.
- N10°–20° E trending faults of the Sarnen and Glarus areas with sinistral lateral component of displacement.
- N–S sinistral and E–W dextral faults of the Wildhorn area.

Fig. 5 Lachon fault, Sanetschpass area, looking NW. Surface displaced by young normal faulting.

5. Recent crustal movements, crustal stresses and neotectonic deformation

It can be shown, that the present orientation of maximum horizontal compressive stress in the upper crust, as determined from fault-plane solutions of earthquakes (see following report p. 127) and in-situ stress measurements (KOVARI et al. 1972, GYSEL, 1975; ILLIES & GREINER, 1978), is very similar to the orientation of maximum horizontal compression 5 to 10 million years ago (PAVONI & MAYER-ROSA, 1978). In northeastern Switzerland the isolines of crustal uplift rates (PAVONI, 1975) as well as the contour lines of the Bouguer and isostatic anomalies caused by the Alps trend at right angle or high angle to the lines of maximum compressive stress. Since the NNW–SSE orientation of maximum horizontal compression is a regional phenomenon observed in central and western Europe the recent vertical movements observed in Switzerland are considered to be mainly caused by horizontal compression.

6. International recent crustal movements meetings in Switzerland

6.1 COORDINATION OF PRECISE LEVELLING IN THE ALPS, 18–19 APRIL 1972 WABERN/BERN

On an invitation by E. Huber, director of the Topographical Survey of Switzerland, geodesists and geophysicists of Austria, France, the German Federal Republic, Italy and Switzerland met on 18–19 April 1972 in Wabern/Bern to coordinate future precise levelling and relevelling in the Alps.

6.2 FIFTH INTERNATIONAL SYMPOSIUM ON RECENT CRUSTAL MOVEMENTS, ZURICH, AUGUST 26–31, 1974

During the last week of August 1974, the Fifth International Symposium on Recent Crustal Movements was held at the Eidgenössische Technische Hochschule in Zurich (ETH-Z), Switzerland. The symposium was organized in collaboration with the International Commission on Recent Crustal Movements (CRCM) of the International Association of Geodesy (IAG) and the Inter-Union Commission on Geodynamics (ICG). Four excursions were organized before and after the symposium to the Rhinegraben area, the Helvetic Alps, the Central Alps and the Jura Mountains. The meeting was attended by 180 earth-scientists, geodesists, geologists and geophysicists from 36 different countries. The proceedings of the symposium were published as a separate issue of Tectonophysics (PAVONI & GREEN, 1975).

6.3 MEETING OF THE SUB-COMMISSION WESTERN-EUROPE OF CRCM, 1–2 MARCH 1977, WABERN/BERN

On an invitation by E. Gubler, chairman of the Sub-Commission, 12 participants from 7 countries met at the Eidgenössische Landestopographie in Wabern/Bern in order to discuss the construction of a map of recent vertical movements of Western Europe.

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