Zeitschrift: Eclogae Geologicae Helvetiae
Herausgeber: Schweizerische Geologische Gesellschaft
Band: 85 (1992)
Heft: 3: Symposium on Swiss Molasse Basin

Artikel: Recent seismicity of the northern Alpine foreland of Switzerland
Autor: Deichmann, Nicolas
DOI: https://doi.org/10.5169/seals-167027

Eclogae geol. Helv. 85/3: 701–705 (1992)

0012-9402/92/030701-05 $ 1.50 + 0.20/0
Birkhäuser Verlag, Basel

Recent seismicity of the northern Alpine foreland of Switzerland

By NICOLAS DEICHMANN *

EXTENDED ABSTRACT

The Swiss national seismograph network, in operation since the mid-seventies, and an additional local network, installed in 1983 in the central part of northern Switzerland, have provided new information about the ongoing deformation and the rheological behaviour of the earth's crust below the Swiss Molasse Basin and Jura Mountains (Mayer-Rosa et al. 1983), Deichmann 1987a, 1990).

The main seismic activity has been observed in two separate areas (Fig. 1). The first comprises the southward continuation of the seismically active Rhinegraben and Dinkelberg regions, which, with a slight westward offset, extends well into the canton of Fribourg (Fröhlich 1991). The second is defined by a diffuse distribution of epicenters extending from the northwestern end of the Lake of Constance to south of the Lake of Zürich. Although the overall activity is low, and the magnitude of the largest earthquake recorded over the last 20 years in this region did not exceed 4.2, it has been possible to construct a large number of well constrained fault-plane solutions (Fig. 2). The resulting focal mechanisms are of strike-slip or normal fault type, indicating a regional shortening with a NNW-SSE orientation, roughly perpendicular to the strike of the Alpine and Jura mountain chains, and a corresponding WSW-ENE extension, parallel to the main axis of the Molasse Basin (Pavoni 1980, 1984, 1987, Deichmann 1990). A characteristic feature of the seismicity of northern Switzerland is the occurrence of many earthquakes in clusters or small swarms. The individual events in a particular swarm exhibit almost identical signal forms and evidently correspond to repeated slip on the same fault (e.g. Deichmann & Garcia-Fernandez 1992). Whereas it is generally not possible to identify the rupture plane from a single fault-plane solution alone, the application of a very precise relative location technique to several earthquake clusters has enabled the mapping of the active faults (Deichmann 1987a, 1990, Deichmann & Garcia-Fernandez 1992, Smit 1989). Such a detailed analysis has been performed for clusters in the eastern part of the Molasse Basin, below the Jura Mountains and in the western part of the Molasse Basin. The results clearly show that deformation of the crust below the Molasse Basin and the Jura Mountains is mainly being accomodated by sinistral as well as dextral strike-slip mechanisms (e.g. Fig. 3) and involves both the sedimentary cover and the crystalline basement.

Hypocenters below northern Switzerland are distributed throughout the entire depth range of the crust (Deichmann 1987b, Pfister 1990). Such a focal-depth distribution

* Schweizerischer Erdbebendienst, Institut für Geophysik, ETH-Hönggerberg, 8093 Zürich.

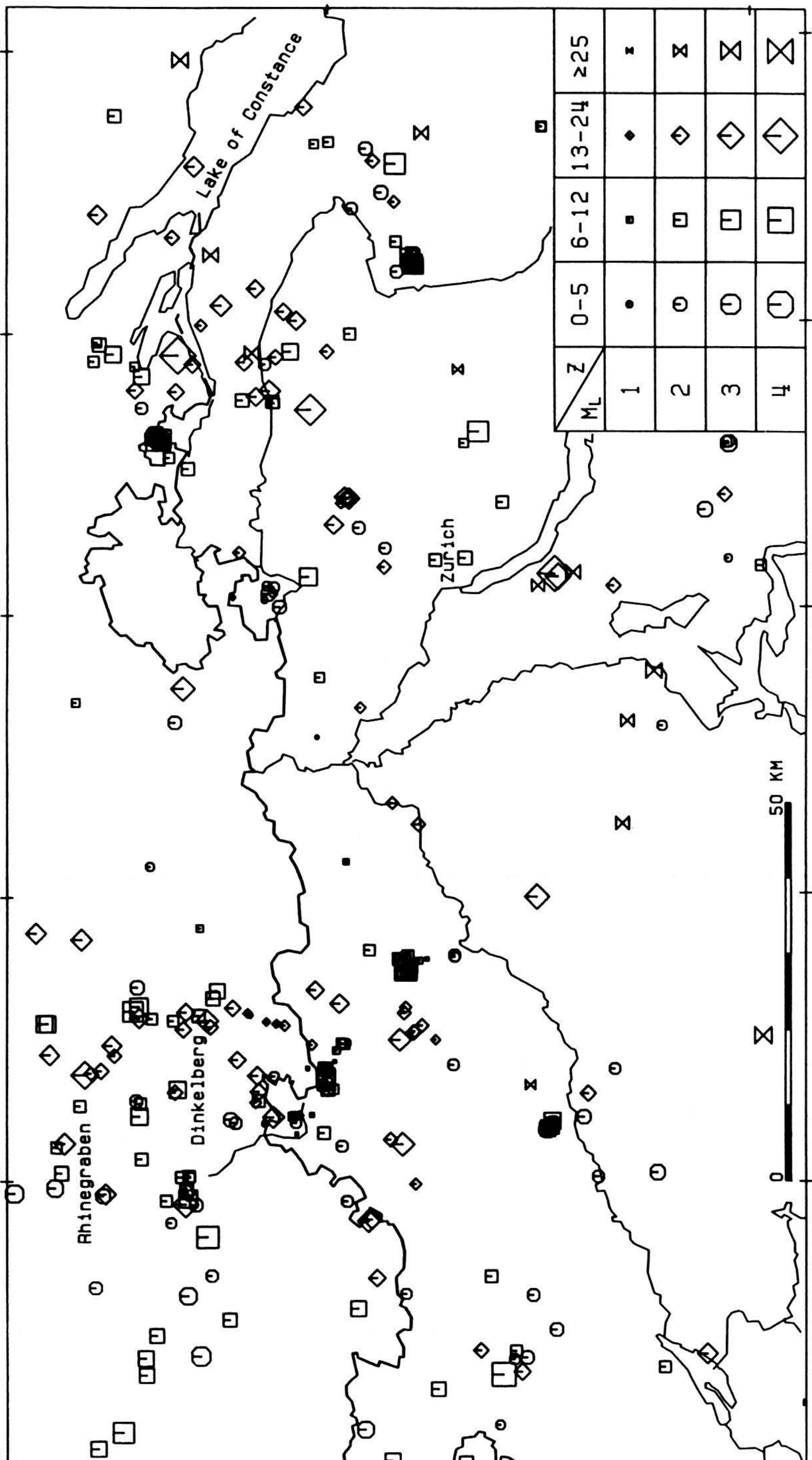

Fig. 1. Epicenter map of northern Switzerland for the period 1983–1991. Magnitudes, Ml, range from about 1 to 4.2; Z is the focal depth in km.

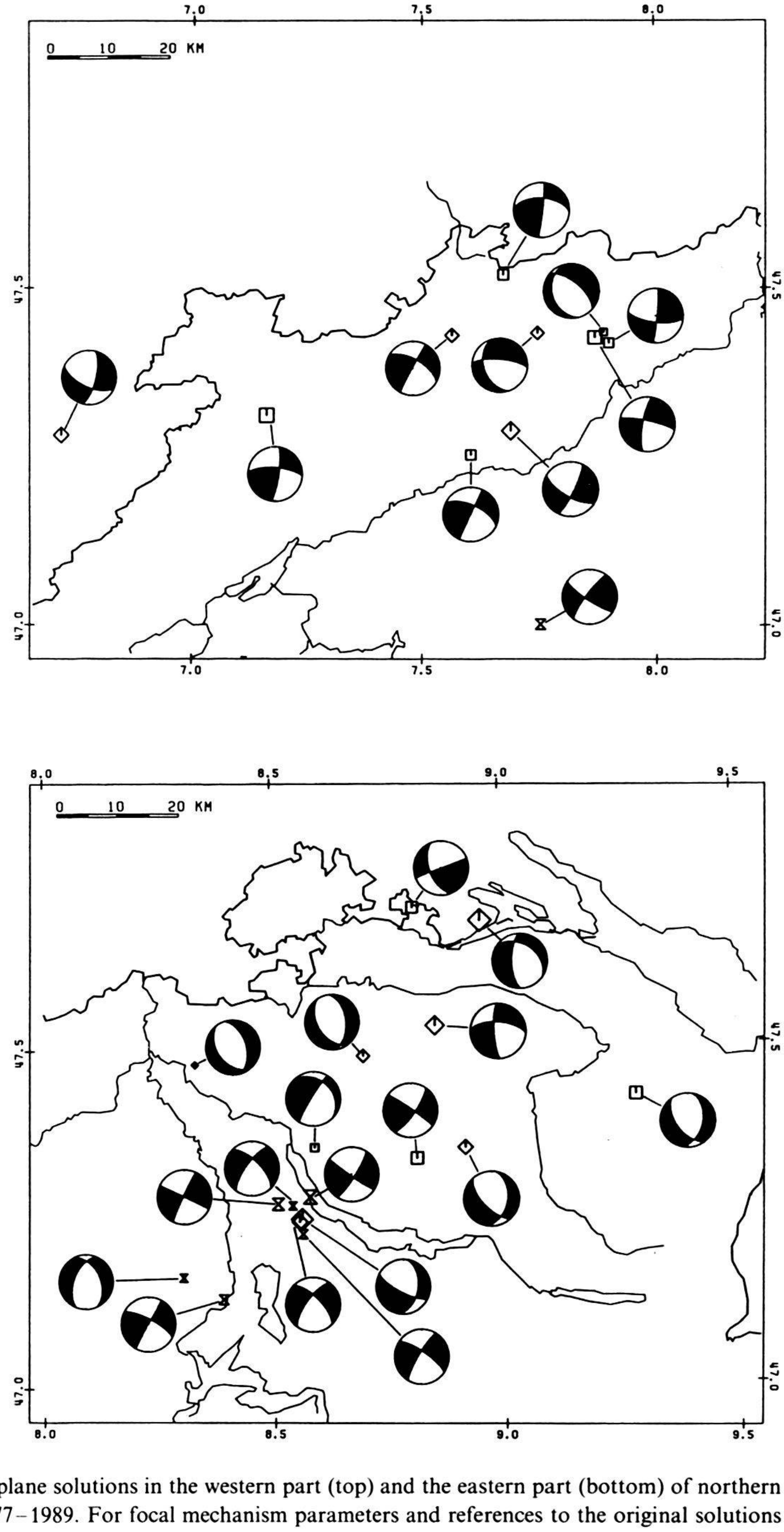

Fig. 2. Fault-plane solutions in the western part (top) and the eastern part (bottom) of northern Switzerland for the period 1977–1989. For focal mechanism parameters and references to the original solutions see Deichmann 1990.

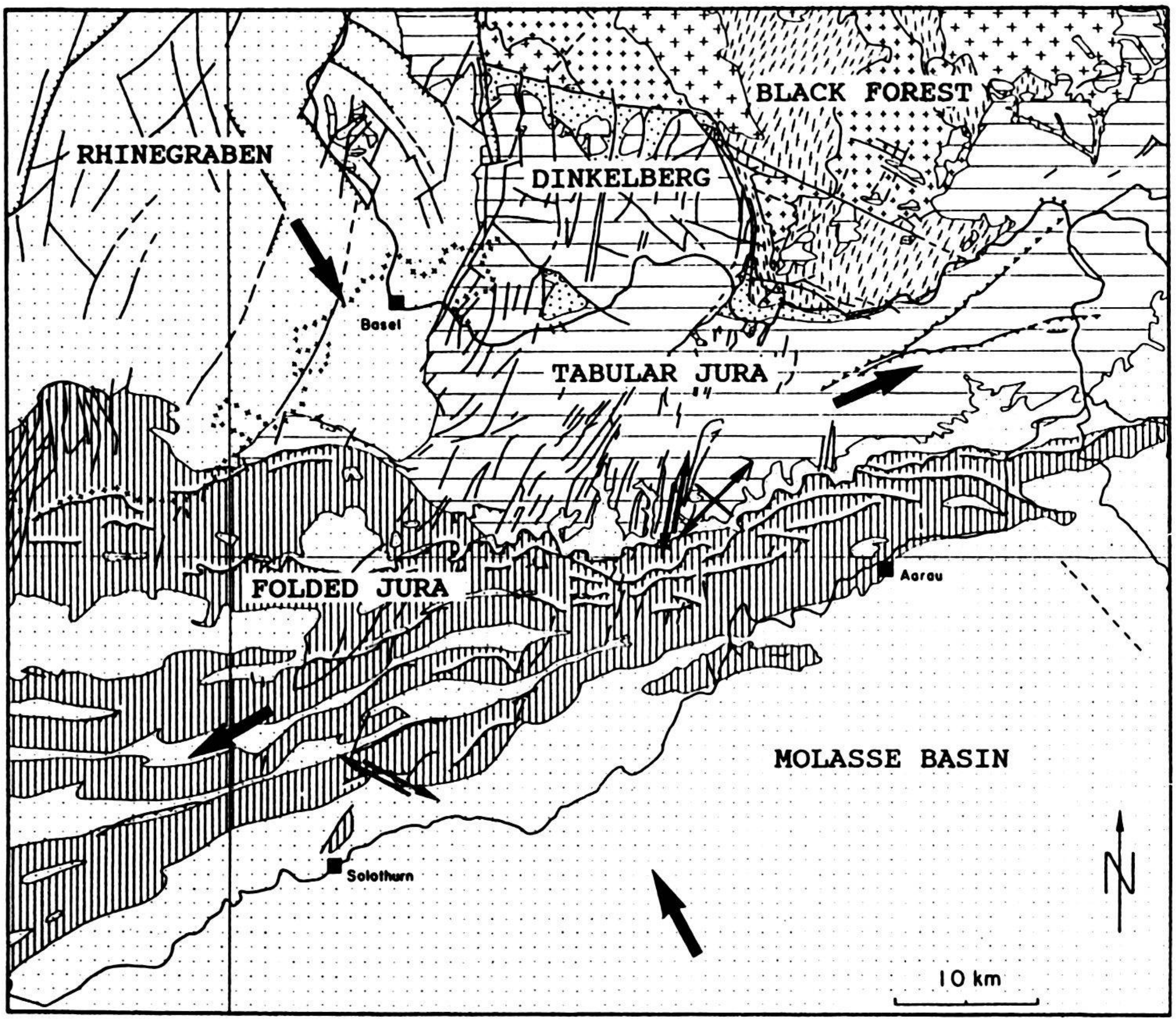

Fig. 3. Orientations of faults and directions of slip (thin arrows) corresponding to the earthquake clusters of Günsberg, Läufelfingen and Zeglingen (Deichmann 1990, Deichmann & Garcia-Fernandez 1992). The large arrows show the directions of maximum crustal shortening and extension.

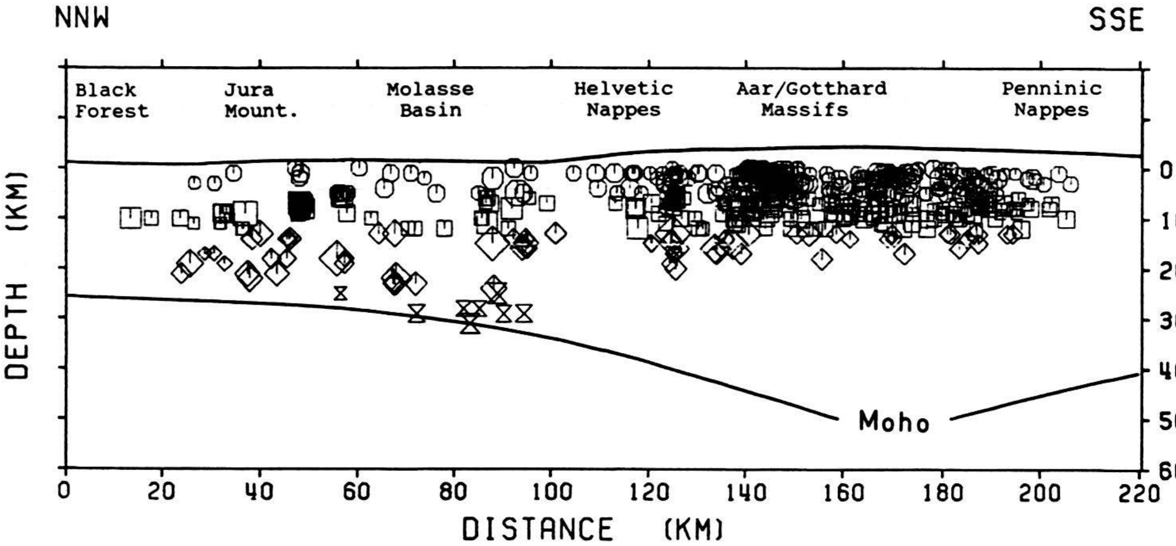

Fig. 4. Focal-depth cross-section projected along a line from Basel to Locarno for the period between Jan. 1975 and Sept. 1990 (after Deichmann & Baer 1990). Only the more reliably located events are included here, selected according to the following criteria: largest difference between epicenter-station azimuths of neighbouring stations $\leq 180°$, number of observation ≥ 11, epicentral distance to nearest station ≤ 30 km, RMS ≤ 0.4 s.

contrasts with what is observed below the Alps and in most other intracontinental settings, where earthquakes are restricted to the upper part of the crust (Fig. 4), (Garcia-Fernandez & Mayer-Rosa 1986, Deichmann & Baer 1990). In addition, surface heat flow, with a regionally representative value of about 80 mW/m^2 (Rybach et al. 1987), is relatively high, and temperatures extrapolated to the lower crust reach values around 600 °C. Such temperatures are well above the 300 °C and 450 °C generally regarded as corresponding to the transition between brittle and ductile deformation for quartz and plagioclase controlled rheologies (Deichmann & Rybach 1989). There is no evidence for either increased strain rates or a mafic lower crust, which could otherwise be reasons for a greater depth of the brittle-ductile transition. It is, however, possible that fluids at high pressures can lower the resistance to slip on preexisting fractures sufficiently to cause brittle failure even at depth ranges where under dry conditions the rock would be expected to deform in a ductile fashion (Deichmann 1990, 1992). The existence of high-pressure fluids in the crust would also explain the occurrence of the observed earthquake swarms (Deichmann & Garcia-Fernandez 1992).

Contribution number 710, Institute of Geophysics, ETH-Zürich.

REFERENCES

DEICHMANN, N. 1987a: Seismizität der Nordschweiz 1983–1986. NTB 87–05, NAGRA, Baden.

– 1987b: Focal depths of earthquakes in northern Switzerland. Annales Geophysicae 5B, 395–402.

– 1990: Seismizität der Nordschweiz 1987–1989, und Auswertungen der Erdbebenserien von Günsberg, Läufelfingen und Zeglingen. NTB 90–46, NAGRA, Baden.

– 1992: Structural and Rheological implications of lower-crustal earthquakes below northern Switzerland. Phys. Earth Planet. Int. 69, 270–280.

DEICHMANN, N. & BAER, M. 1990: Earthquake focal depths below the Alps and northern Alpine foreland of Switzerland. In: The European Geotraverse: Integrative Studies. (Ed. by R. Freeman, P. Giese and St. Mueller). European Science Foundation, Strasbourg, France, 277–288.

DEICHMANN, N. & GARCIA-FERNANDEZ, M. 1992: Rupture geometry from high-precision relative hypocenter locations of microearthquake clusters. Geophys. J. Int., in press.

DEICHMANN, N. & RYBACH, L. 1989: Earthquakes and temperatures in the lower crust below the northern Alpine foreland of Switzerland. In: Properties and Processes of the Lower Crust. (Ed. by R. F. Mereu, St. Mueller and D. Fountain). Am. Geophys. Union, Geophysical Monograph 51, IUGG Vol. 6, 197–213.

FRÖHLICH, A. 1991: Seismotektonik der Westschweiz unter Berücksichtigung der Erdbebenserien von Freiburg (1987), Romont (1988) und Boltigen (1989). Diplomarbeit, Institut für Geophysik, ETH-Zürich.

GARCIA-FERNANDEZ, M. & MAYER-ROSA, D. 1986: Improved hypocentral parameter determination using secondary regional phases. Rev. de Geophysica 42, 175–184.

MAYER-ROSA, D., BENZ, H., KRADOLFER, U. & RENGGLI, K. 1983: Inventar der Erdbeben 1910–1982 und Karten der Magnitudenschwellen-Werte 1928–1982. NTB 83–08, NAGRA, Baden.

PAVONI, N. 1980: Crustal stresses inferred from fault-plane solutions of earthquakes and neotectonic deformation in Switzerland. Rock Mech., Suppl. 9, 63–68.

– 1984: Seismotektonik Nordschweiz. NTB 84–45, NAGRA, Baden.

– 1987: Zur Seismotektonik der Nordschweiz. Eclogae Geol. Helv. 80, 461–472.

PFISTER, M. 1990: Gemeinsame Auswertung von Erdbeben-, Refraktions- und Reflexionsdaten in der Nordschweiz. Diplomarbeit, Institut für Geophysik, ETH-Zürich.

RYBACH, L, EUGSTER, W. & GRISSER, J.-C. 1987: Die Geothermischen Verhältnisse in der Nordschweiz. Eclogae Geol. Helv. 80, 521–534.

SMIT, P. 1989: Seismotektonische und aeromagnetische Untersuchungen in der Region Ramsen (Kanton Schaffhausen). Diplomarbeit, Institut für Geophysik, ETH-Zürich.