SEISMIC RISK ANALYSIS IN SOUTHWEST-GERMANY
Based on Satellite RADAR - DATA

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ABSTRACT

The integrated analysis of geologic and seismologic data, field observations, lineament data derived from satellite radar images (ERS-1, SIR-C) from Southwest-Germany allows a better understanding of the tectonic setting and a more detailed identification of fault zones. Comparisons of lineament maps with seismotectonic data suggest that some of the most prominant visible lineament zones are deap-seated structures. Radar-lineament maps were compared with available isoseismal maps of stronger earthquakes (intensity of 6-8 on the MSK-scale). The interpretation of satellite radar data contributes to a better knowledge of the influence of local structural conditions on seismic wave radiational propagation and on ground motions.

1. GEOTECTONIC SETTING

Southern Germany as a tectonic and seismotectonic unit has a shape of a triangle, triangle, bordered by the following structures: the Upper Rhinegraben in the west, the Prealpine Molasse basin in the south and the Bohemian Massif in the northeast (Fig.1). Beginning with the Swabian Jura earthquake in 1911 the seismic activity in Central Europe is concentrated to this area. As far as it can be seen from historic records from the time before 1800 a shock of the quality as those in 1911, 1943 and 1978 has not been observed in this area (SCHNEIDER,1979,1980).
As can be deduced from fault-plane solutions, the prominent type of seismotectonic motions consists of horizontal strike slip motiones along NNE or NW directions (Fig.2). From the distribution of epicenters and the orientation of fault planes it can be concluded that the axis of main principal stress is oriented about NNW (SCHNEIDER, 1980, GRÜNTHAL & STROMEYER,1995).

2. RADAR LINEAMENT ANALYSIS

The present study is an attempt to integrate various data sets (satellite radar data, seismotectonic data, geologic and geomorphologic field data) to obtain a general better understanding of the tectonic setting and to improve earthquake vulnerability maps.

ERS-1 has taken several complete SAR coverages from entire Germany. The processing of the data was done in the German Processing and Archiving Facility (D-PAF) at German Remote Sensing Data Center (DFD) of the DLR/ Oberpfaffenhofen.

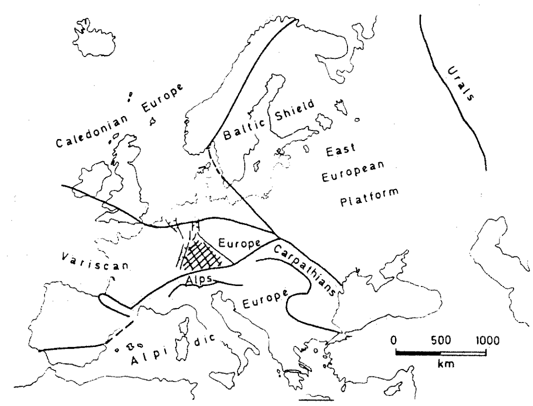

Fig.1: Tectonic Units in Europe (Schneider,1980)

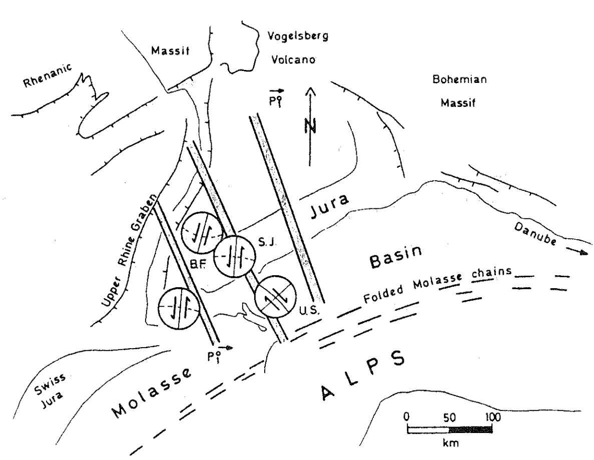

Fig.2: Directions of Largest Principal Stresses in Southwest-Germany (Schneider,1980)

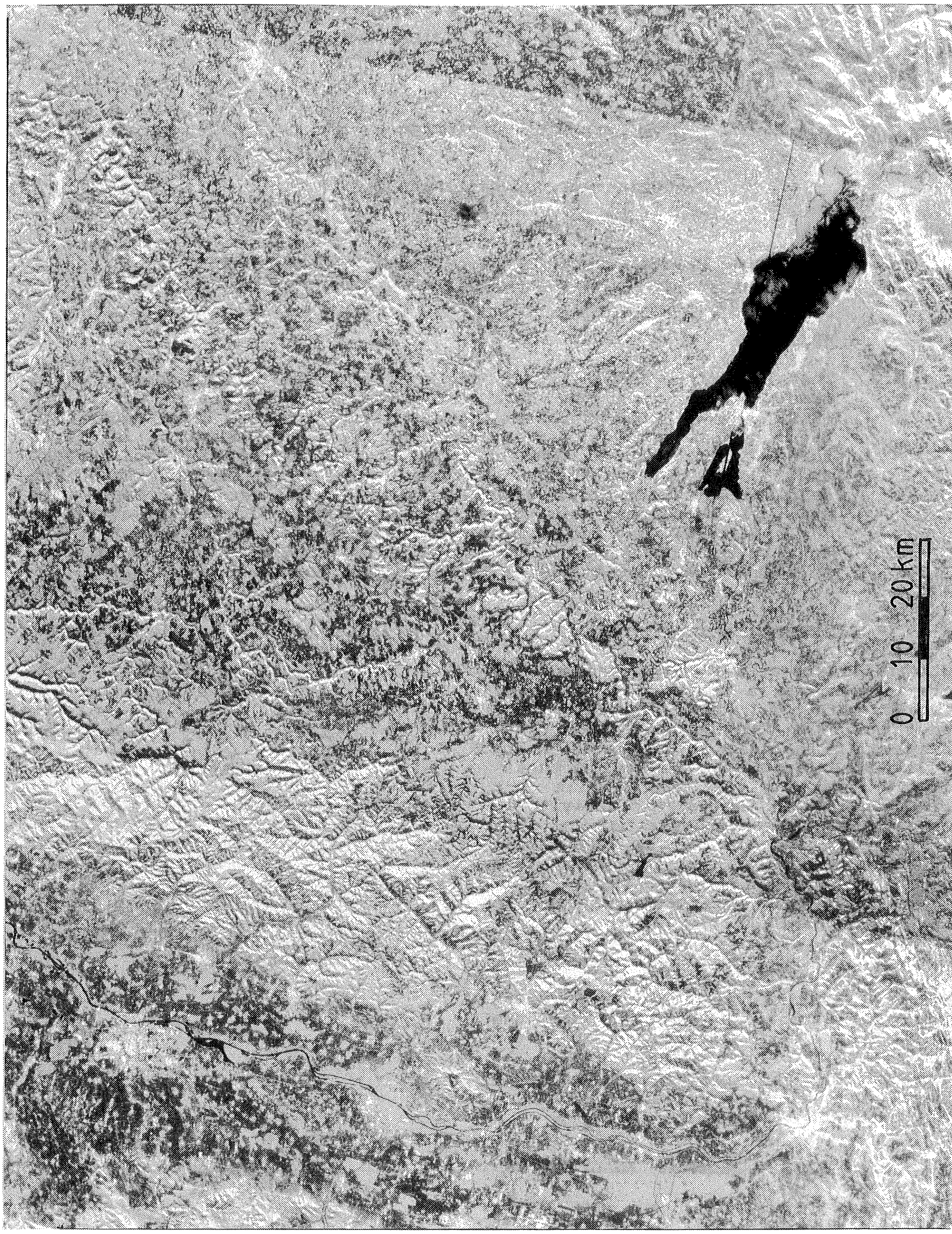

Fig.3: Radarmap of Southwest-Germany (German Aerospace Research Establishment, DLR, Oberpfaffenhofen, 1994, Kosmann et al.,1994)

The geocoded terrain corrected SAR images are the basic input data sets for the generation of mosaics, the Radarmap Germany (KOSMANN et al.,1993). The precise gecoding procedure guarantees a geometric accuracy of 30 m. This radar map (Fig.3) as well as SIR-C- X-Band data from the Ueberlingen test site were used for lineament analysis. (The term lineament is a neutral term for all linear, rectilinear or slightly bended image elements.) The radar images, because of their coverage allow an interpretation of lineaments and of structural trends that would have been impossible from field mapping alone. The mapped lineaments are represented in Fig.4.

The nature of the linear traces visible on ERS-1-image mosaics from SW- Germany variies along strike and is represented by some combinations of linear steep valleys, especially in the Black Forest Area, and depressions, linear hydrographic features and drainage segments,linear hills, ridges and abrupt ending straight scarp lines. Available geologic and geophysic data indicate correlations of the distinct expressed lineaments with fault zones in the subsurface. Comparisons of lineament maps with seismotectonic data suggest that some of most prominent lineament zones are deep-seated structures as for example the Hegau-fault zone (SMIT, 1989). The pattern of linear features corresponds to the tensional stress field known in this area. The radar imageries from SW-Germany , thus, provide essential clues to the tectonic setting. The integrated analysis of geologic and seismologic data as well as field observations with lineament data derived from satellite radar images from Southwest-Germany allows the identification of fault zones that might be of importance during seismic events and might influence further damage intensities. Precise delineation of these faults can be a veritable input in seismic risk analysis.

3. COMPARISON OF ISOSEISMAL MAPS WITH LINEAMENT MAPS

Damage resulting from an earthquake variies spatially. Within the same zone of shock intensity, the damage may vary locally, being a function of both the type of structure and ground conditions, as for example of faults and fractures. Investigations of groundstructure interactions form the necessary basis for the analysis and evaluation of the earthquake damage risk.

The interpretation of satellite radar data contributes to a better understanding of the influence of local soil and structural conditions on seismic wave radiational propagation and on ground motions:

Lineament maps derived from interpretations of ERS-1-data were compared with available macroseismic ob-servations of stronger earthquakes (intensities of 7 to 8 on the MEDVEDEV -SPONHEUER - KARNIK-Scale). As an example ist shown the isoseismal map of the 16.11.1911 event.

The correlation and combination of the 16.11.1911-isoseismal map with the radar lineament map (Fig.4 and 5) clearly

Fig.4: Lineament Map based on Evaluations of Satellite Radar Imageries from Southwest-Germany

indicates that areas of high damage intensities are related to surface traces of larger faults and to areas with a dense lineament pattern. They are concentrated in areas of crossing lineaments. A combination of epicenter and lineament map is presented in Fig.6. Epicenters are concentrated predominantly in areas of crossing lineaments (Theilen-Willige, 1995).

Fig.5: Combination of the Macroseismic Map of the Swabian Jura Earthquake(16. 11.1911, Schneider,1979) and the ERS-1-derived Lineament Map

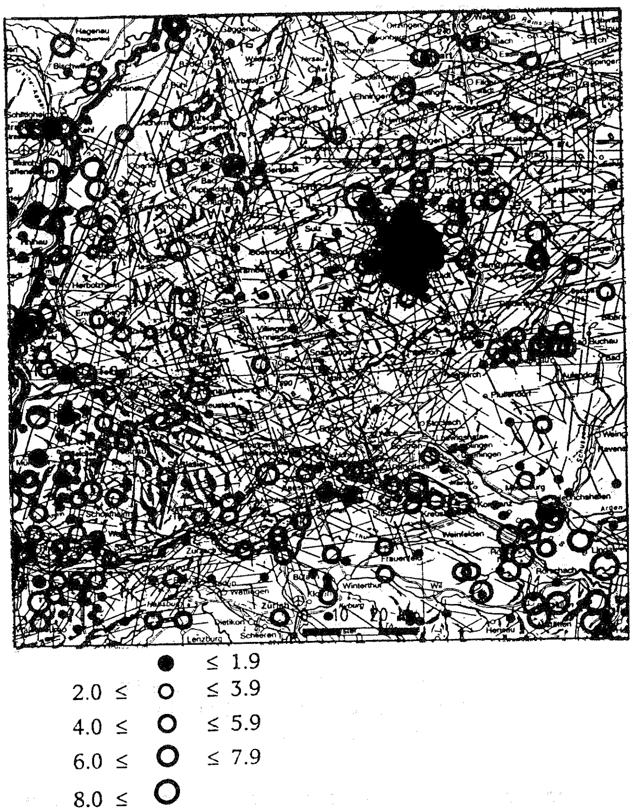

Fig.6: Comparison of Earthquake Epicentre Distribution (Bundesanstalt f. Geowissenschaften und Rohstoffe, Hannover, 1991) with Radarmap derived Lineaments

4. LANDSLIDES

Slope-instabilities developed in the superficial quaternary deposits and tertiery sediments during the 16.11.1911-event demonstrated the existence of potentially hazardous secondary effects of earthquakes. Various types of landslides are common in parts of SW-Germany as for example in the northwestern part of the Lake Constance area. There landslides occur after nearly every wet season of the year. The detailed interpretation of satellite radar and of LANDSAT TM-data, as well as of aerial photographs allows the detection of lineaments that are coincident with fault and fracture systems influencing slope instabilties. Thus, lineament analysis contributes to landslide hazard zoning and to the location of areas susceptible to slope failure. This is of fundamental value for planning purposes.
Satellite radar data from Southwest- Germany have demonstrated their value as a tool for earthquake damage-risk evaluation.

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