

Field Geological observations around Rhein Graben in Germany:

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Abstract:

Many geological localities were visited in Germany, especially in the area of upper Rhein Graben. This area was well known by the geologists as an active area due to the action of tension stress field. This area was manifested by hydrothermal activities and earthquakes. The topographic features which are observed in the area are the consequence of these Tectonic activities around Rhein river. The aim of this work is to describe and measure some structural elements in the above mentioned area and to interpret their origin.

مشاهدات جيولوجية حقلية حول منخفض الراين في ألمانيا:

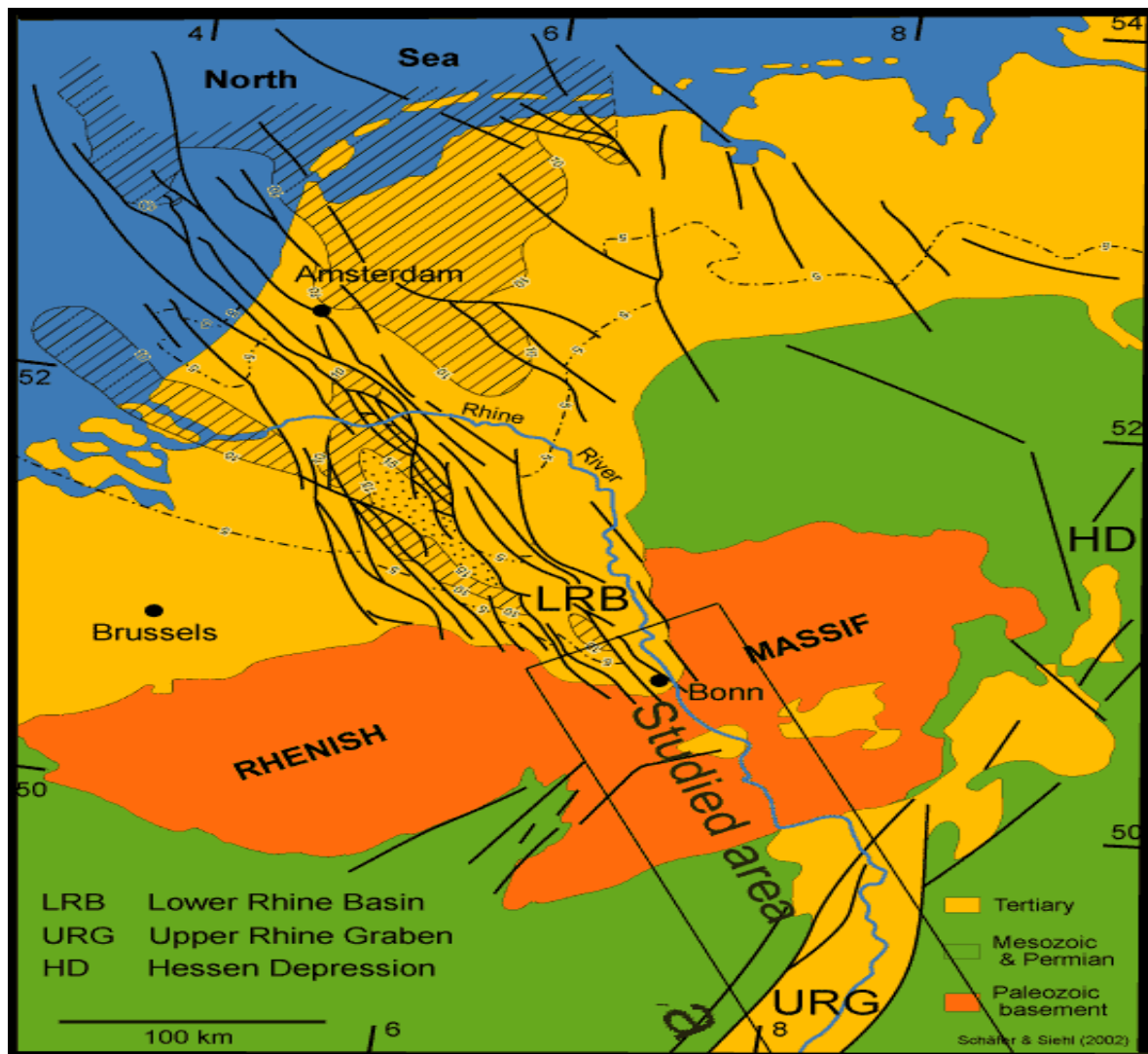
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مواقع جيولوجية عديدة تمت زيارتها في ألمانيا خاصة المناطق الممتدة حول نهر الراين والتي تعتبر من المناطق المعروفة جيداً لدى الجيولوجيين باعتبارها مناطق متأثرة بقوة شد لا يزال تأثيرها مستمر حتى الوقت الحاضر وذلك من خلال النشاط الحراري والزلالي في المنطقة. إن المظاهر الطبوغرافية التي شوهدت في المنطقة تعتبر نتيجة لهذا النوع من قوى الشد. إن الهدف من هذا العمل هو لوصف وقياس بعض العناصر التركيبية في المنطقة المذكورة وتفسير منشأها.

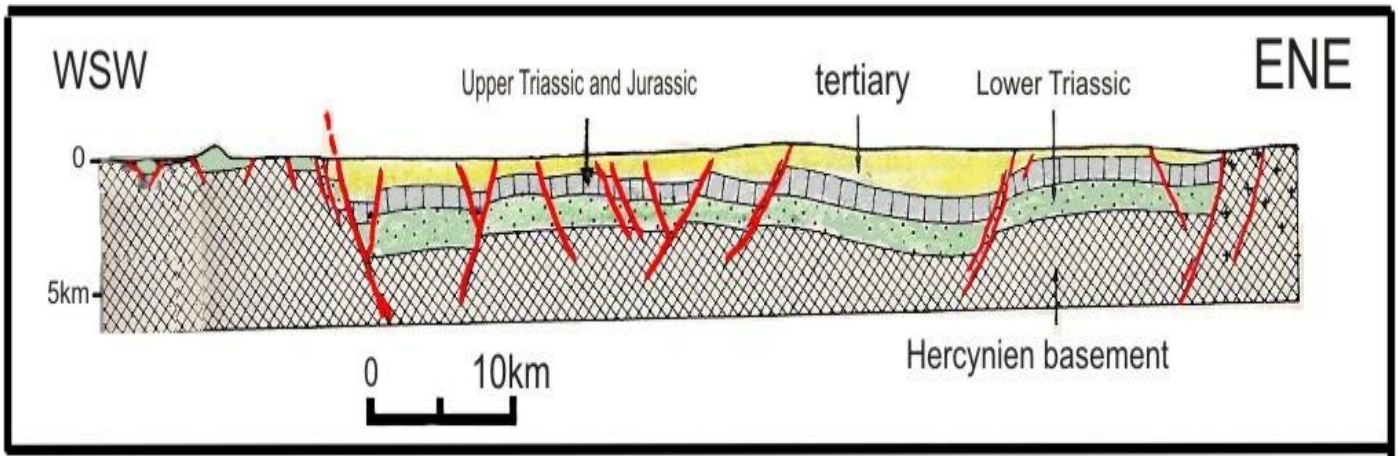
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Introduction:

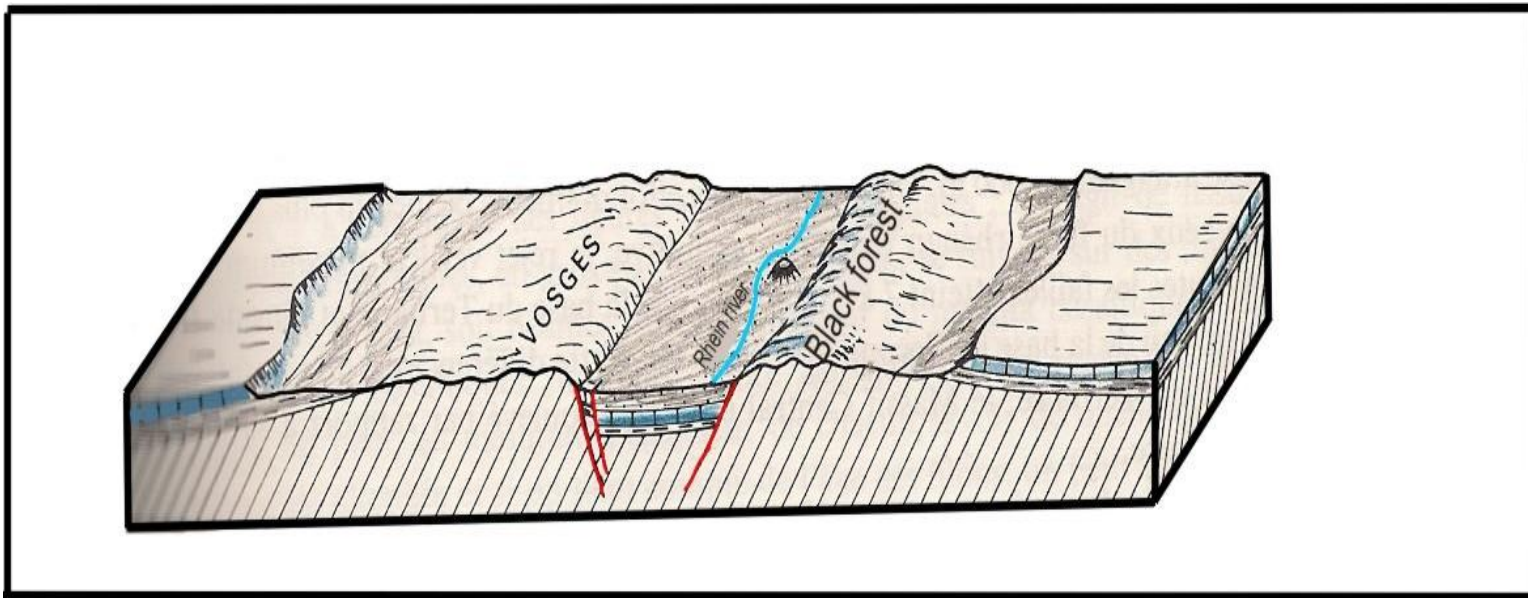
The western part of Europe was cut by Graben structures of about 1000 km long (Mattaue 1980). The Rhein Graben is the well known between them Fig(1). This Graben represents long depression filled by Cenozoic deposits. It borders from east and from west by two very clear reliefs of normal faults (Fig2, Fig.3). The relief of the Voges and the Black Forest near the border of Germany and France are the consequence of rifting. The tension field in this area was associated with volcanic activities. Two episodes of these activities can be differentiated, one during the Permian age of acidic volcanism. The other episode was during the Tertiary and it is of basic type of volcanism. Tertiary deposits were found only inside the Graben and not on other parts (A. Schäfer & P. Aziegler & al 2005). Conglomerate deposits were found near the relief of faults, & in the center of depression fine deposits were found & some time associated with evaporite deposits



Figure(1) location map of the studied area



Figure(2) cross section through Rhein Graben (from Sittler 1967)



Fig(3) simplified block diagram of Rhein graben passed by black forest and Vosges (from Mattauer 1980)

Tectonic history of the studied area:

The tectonic history of the area can be concluded as follows :
(Ziegler & al 2005, Wilson R. & al 2001)

- 1- During the upper carboniferous (stephanian to early Permian) wrench faults caused disruption of the variscan orogen. at the end of early Triassic time . the crust thinned down on regional scale to 28- 35km.

2- During late early Permian the temperature of the asthenosphere returned rapidly to ambient level.

Re - equilibrium of lithosphere commenced and persisted during Mesozoic. Minor intra Mesozoic tensional lithosphere system of the European Cenozoic rift system area in the Rhine rift system area, the lithosphere had re-equilibrate with the asthenosphere at the end of Cretaceous time at depth of (100 - 120) km.

3- During latest Cretaceous and Paleocene intra plate compressional stress projected from evolving Alps and Pyrenees into their land cause broad lithospheres warping and basin inversion in the area of west.

4-European Cenozoic rift system developed by passive rifting in fore land of Alps and Pyrenees in response to build up of a collision intra plate compressional stress field that permuted in time.

5- During late Eocene initial rifting phase in the area involving reactivation of preexisting late Paleozoic and Mesozoic crystal discontinuities.

6- The Miocene to recent evolution of European Cenozoic rift system was Governed by W - N W directed compressional stress originated at alpine Collision zone. The thin rift system remained active until the present When the graben of Massive central Rhine and Rhone valley became Inactive during the early Miocene.

7- Plume - related thermal thinning of the Mantle lithosphere during the Miocene and Pliocene to Pleistocene is held responsible for the reduction Of lithospheres thickness to 50 - 60 km. beneath Rhinish massive and the Massive central and their progressive uplift.

Description and measurement of structural element in the area:

Surface structural element which are recognized in the studied area are :(Davis&al 1996,Mattauer 1980)

1- Folds

60 km to the west and south west of Bonn city many geological observation were done . the Devonian rocks are cropping . they are folded , the direction of fold was NE-SW (about N060E) .these rocks are affected by tow phases of folding of the same direction because the thrust plans are refolded .

The lower Devonian rocks in the investigated area are consisting of sandstone and marls (continental rocks) . the middle and upper Devonian are presented as remnant on the elevated lower Devonian rocks . many joints of direction NW-SE with dip sub vertical are related to the compression and they are parallel to the direction of it .



Figure(4) tow folds in the Devonian rocks of NE-SW direction .



Figure(5) normal fault in the upper bend of fold in figure (4)

2-Faults

The faults are associated either with field of compressions stress or with field of tension stress . the first type is due to plates convergence .they are either reverse faults or thrust . many of these faults are recognized in Devonian rocks with direction parallel to the folds. Fig.(6) represent fault plain with traces of slickenside on it.

this traces of slickenside give us the type of movement that happened on the fault plain.

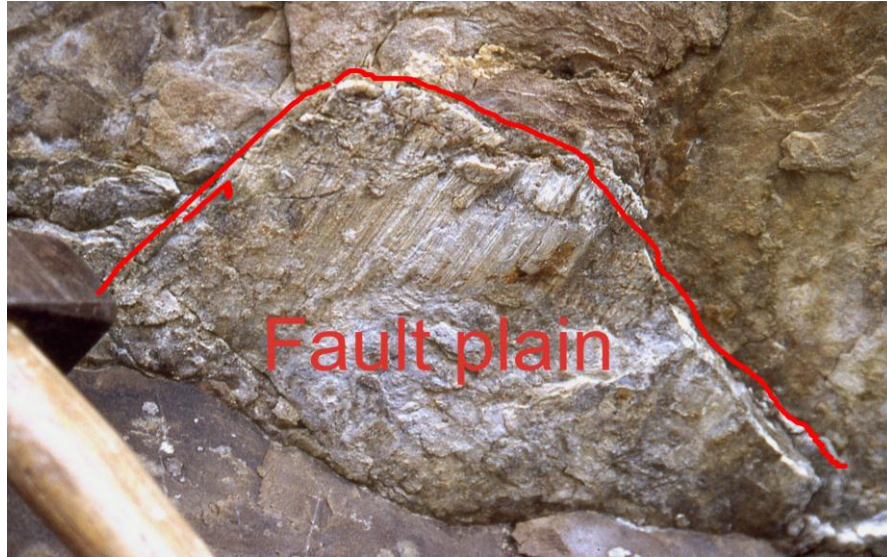


Figure (6) slicken side on the foot wall of reverse fault in the Devonian rock

The normal faults that bound the Graben of Rhein are of direction NE-SW and dips to ward each other . the displacement along these large normal fault reach about 5000 m (Mattuer 1980).

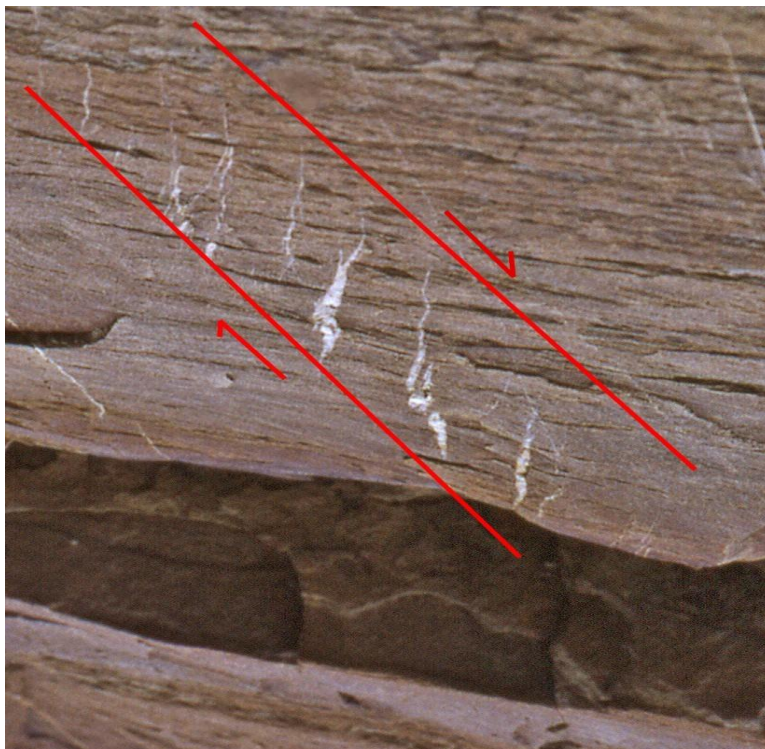
Small scale normal fault with displacement of about 10 cm are related to the same stress field of tension in the area Fig(7)



Figure(7) small scale normal fault in thick sandstone bed of Devonian rock

3- Veins

They are opening mode fractures formed under high fluid pressure and filled with mineral deposited from the water they are important indicators of local stress conditions . some time they form en echelon arrays with in shear zone Fig.(8). The sense of shear of en echelon vein arrays can be determine in the field . it is either dextral or sinistral arrangement . The growth direction and change in growth direction of minerals with some veins record the history of opening of fractures trough time (Mattaueer 1980) in limestone and other easily soluble rock types these Veins are associated with joint stylolitic which are irregular surfaces of dissolution induced by high stress . the joint stylolitic are perpendicular to the Veins and the direction of its peak are parallel to the major force of compression .

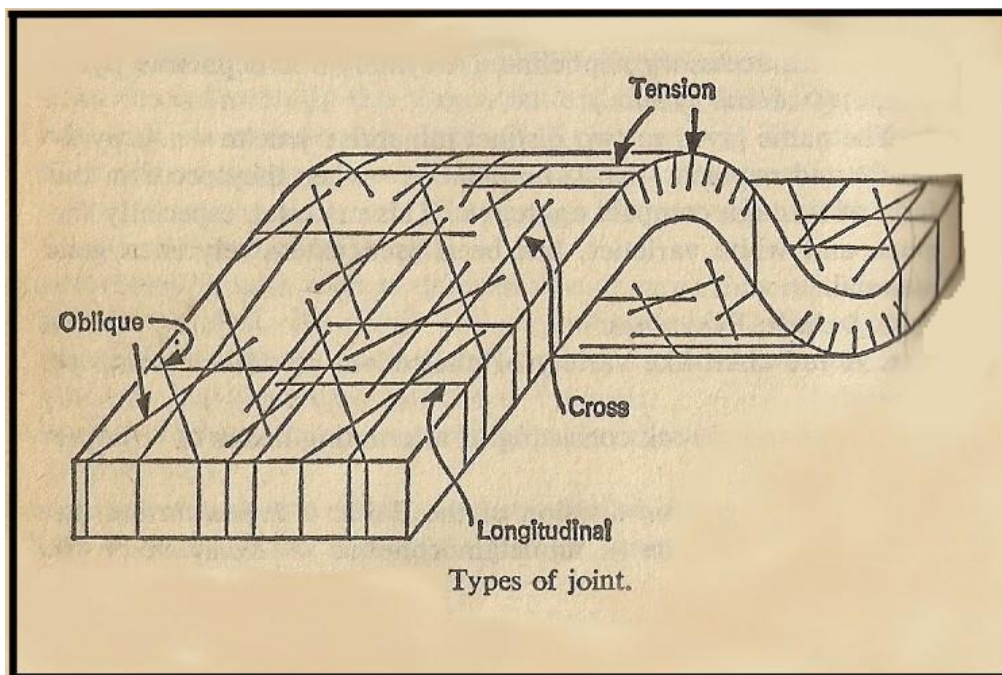


Figure(8) Veins arranged en echelon along dextral shear zone

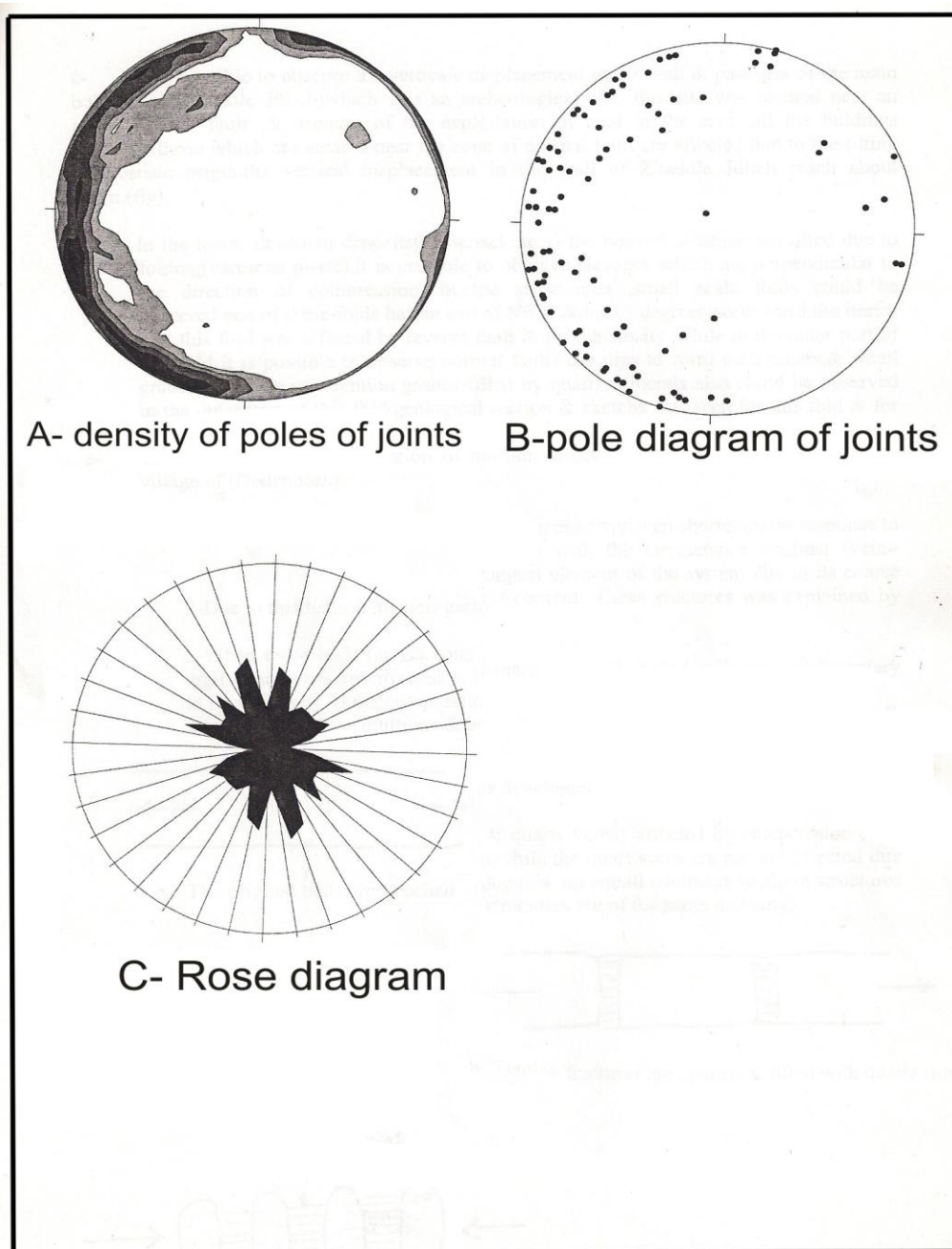
4- Joints

The joint are oriented systematically over large area . they are indicative of the orientation of stress field during deformation . they are discrete brittle fractures in a rock along which there has been little or no movement parallel to the plan of fracture , but slight movement normal to it. Fractures may be caused by shrinkage due to cooling or desiccation or to the un loading of superincumbent rock by erosion or tectonism (Ailsa& al 2003)

In the studied area there is often a set of joints is either due to regional deformation or due to uplift and unloading or they formed due to shrinkage of igneous rock due to cooling. A station of measurement of joints was effectuated about 25 km to the south of Bonn city (Hill of Stenzelberg) which located to the west bank of Rhein river. Some measurement of joints was done in the area (100 measurement of joint) the Hill is consist of Latite (intermediate volcanic rock) . these rocks are affected by joints , some of them are cylindrical and filled by iron minerals . large Hornblende crystals where observed on the surface of these volcanic rocks . the crystals are elongated up word . the stereographic projection of these joints indicated that there is one direction of joints parallel to the direction of normal faults which are originated during Tertiary age and they are perpendicular to the direction of maximum stretch Fig(9)



Figure(9) Block diagram represent the different type of joints



Figure(10) A , B , C computer drawing of 100 measurements of joints in Stenzelberg hill ,Germany.

Discussion:

In the studied area we are tried to compare the tectonic event that affected during the different geological age around the upper Rhein Graben with the structural elements that was delineated in the area and which are the consequence of these tectonic events

The folds and reverse faults and thrust which cut the Devonian rocks during variscan orogeny are of direction NE-SW and all of these structural elements which are originated on the Devonian rocks have this direction.

The tertiary sediments are deposited on folded Devonian rock and an angular unconformity between them was observed.

It seems that the rift activities happened during two separated events one before Triassic age and the other was post Triassic age because there are many igneous dykes that are stopped against the Triassic deposits while there is another set of dykes cut in the Triassic and post Triassic. The minor structures like faults and veins which are measured in the area coincide with the major structures and give also the same idea about the direction of stress fields.



Figure(11) Igneous dyke cut only in Paleozoic rocks

Conclusion:

The studied area was located in Germany along the upper Rhein Graben. Two episodes of stress were affected in the area, one due to compression because the Devonian rock which was cropping out was folded and cut by reverse and thrust faults. The direction of this compression is NW-SE.

The second episode of stress was due to tension, one during Paleozoic and the other post Paleozoic. Many igneous rocks and dykes were observed due to volcanic activities during these episodes of tension and the rift of Rhein Graben was originated due to this tension.

Many structural elements of compression and tension fields of stress were observed and measured and by these elements we can determine the stress direction.

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