J KAU: Earth Sci., vol. 5, pp. 177-201 (1412 A.H./1992 A.D.)

Structural Setting of Jabal Abu Ghurrah Area, Wadi Fatima, West-Central Saudi Arabia

FAWAZ A.R. ZAKIR and ADEL R. MOUSTAFA
Faculty of Earth Sciences, King Abdulaziz University, Jeddah, Saudi Arabia

ABSTRACT. Detailed field mapping and structural study of J. Abu Ghurrah area indicate that the uppermost Precambrian sediments and volcanics of the Fatima Formation were deformed by NNW-SSE tangential compression. The styles of deformation include flexural-slip folding forming a large, ENE to NE plunging, overturned syncline and low-angle thrusting in a hinterland dipping duplex. The floor thrust of the duplex is a décollement between the 150 meters thick andesite sill and the underlying limestone beds of the middle Fatima member. The roof thrust of the duplex has the largest displacement among the mapped thrusts. The duplex was formed by continued shortening of the area as the thick andesite sill of the middle Fatima member acted as a rigid and brittle beam that resisted folding and failed by low-angle thrusting. Layer-parallel shortening by minor folding and thrusting is also common in the area and represents an early phase of deformation.

Introduction

Jabal (J.) Abu Ghurrah lies in the northeast side of Wadi Fatima in the west-central part of the Arabian Shield (Fig. 1). It represents the northeasternmost outcrop of uppermost Precambrian sedimentary rocks of Wadi Fatima. The outcrops of the Fatimah Formation are consistently shortened by northeast-southwest trending folds. Nebert *et al.* (1974) systematically mapped these outcrops of the Fatima Formation and their work represents the only comprehensive study of Wadi Fatima area, besides the regional compilation of Moore and Al-Rehaili (1989).

The objective of the present work is to study the structural setting of J. Abu Ghurrah as a representative segment of the Wadi Fatima area. Detailed field mapping on a scale of 1:12,500 and detailed field study of the meso- and macrostructures of J.

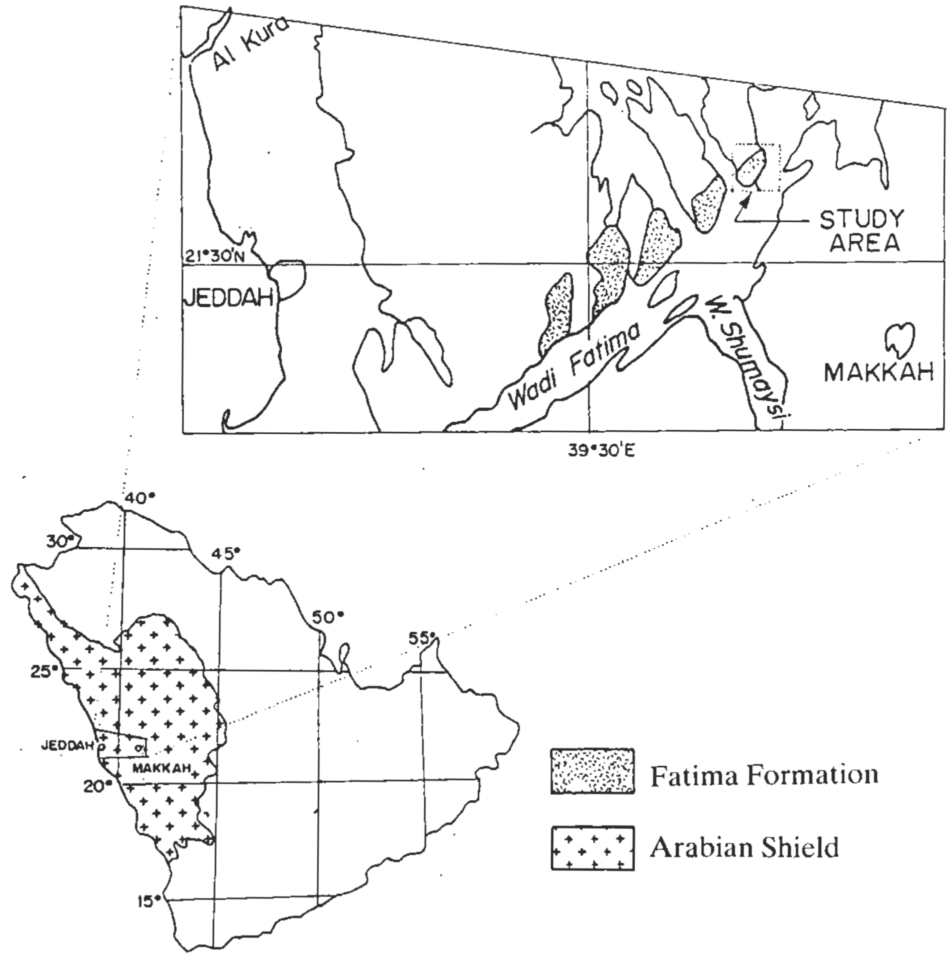


FIG. 1. Location map of the study area.

Abu Ghurrah area are conducted in the present study. The mapped area is bounded by latitudes 21° 34′ 30″ N and 21° 36′ 30″ N and by longitudes 39° 39′ 13″ E and 39° 41′ 21″ E, occupying an area of about 11 square kilometers.

Map Units

The exposed rocks of J. Abu Ghurrah area belong to two main series of rocks, namely the pre-Fatima basement and the Fatima Formation (Fig. 2). The pre-Fatima basement rocks consist mainly of granites intruding gabbroic rocks. Both are intruded by E-W oriented andesite dikes and are covered by volcanoclastics. The granites are 773 ± 16 m.y. old (Rb/Sr whole rock ag e; Duyverman *et al.* 1982).

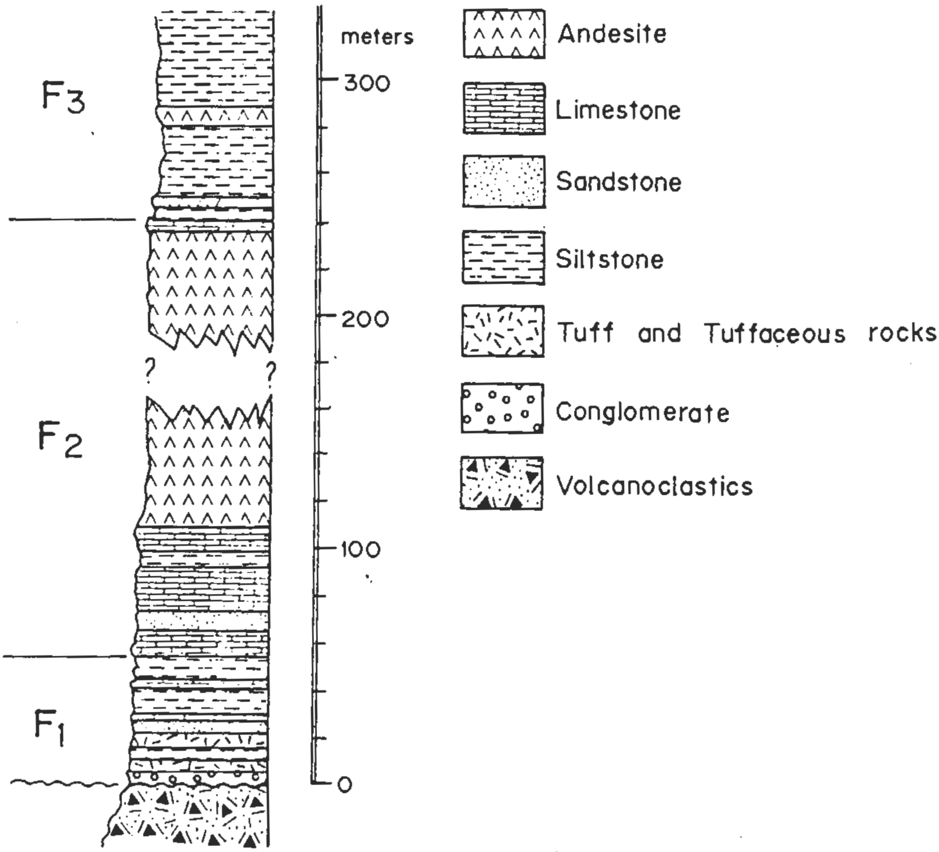


FIG. 2. Simplified stratigraphic section of J. Abu Ghurrah area showing the three members of the Fatima Formation (F1 through F3) and the underlying pre-Fatima volcanoclastics.

A volcanic vent exists at J. Sidr to the northwest of J. Abu Ghurrah. J. Sidr is made up of volcanic breccia and andesite with several granite xenoliths that sometimes have exceptional dimensions. The rocks of J. Sidr are disconformably overlain by the sedimentary rocks of the Fatima Formation.

The Fatima Formation consists of non-metamorphosed to very slightly metamorphosed (lower greenschist facies) sedimentary rocks (Moore and Al-Rehaili 1989). These sedimentary rocks are intruded by andesite sills. The unconformity between the sedimentary rocks of the Fatima Formation and the underlying pre-Fatima volcanoclastic beds is angular in the northeastern part of the area. A basal conglomerate bed locally exists at the base of the Fatima Formation.

Quaternary terraces, alluvial fans, and wadi alluvium and colluvium cover the plains surrounding J. Abu Ghurrah and are the youngest exposed sediments in the study area.

Fatima Formation

The term Fatima Formation was introduced by Brown and Jackson (1960) after the original name "Serie du Wadi Fatima" which was given by Karpoff (1955). This formation consists of three units which are a lower clastic unit of a characteristic green color, a middle carbonate unit of a predominant yellowish white color, and an upper clastic unit of a characteristic brick red color interbedded with pyroclastics and volcanics (Fig. 2). These three units are named herein the lower, middle, and upper Fatima members respectively. Moore and Al-Rehaili (1989) gave these three members formational ranks and named them the Baqqar, Shubayrim, and Daf Formations from base to top.

The lower Fatima member consists mainly of green siltstone, claystone, shale, and fine- to coarse-grained arkosic and tuffaceous sandstone. A basal conglomerate bed exists in some places of J. Abu Ghurrah and includes sub-angular fragments of the underlying granite and volcanoclastic beds. Cross stratification, current ripple marks and mud cracks characterize this member and indicate a shallow water environment of deposition.

The middle Fatima member includes a rosy to brownish red, medium-grained sandstone unit at the base and a yellowish white to greyish white limestone unit at the top. The sandstone unit pinches out toward the northeast where the lower Fatima member is directly overlain by the carbonate unit of the middle Fatima member. A stromatolitic limestone bed characterizes the top of the limestone section. A thick andesite sill exists near the top of the middle Fatima member. The thin limestone section overlying the sill is thermally baked into white and olive green marble that marks the upper contact of the middle Fatima member.

The upper Fatima member consists of brick red siltstones with a few sandstone beds. Ripple marks, gradded bedding, and mud cracks are the common sedimentary structures in this member. The siltstone beds are interbedded with andesite sills and a few volcanoclastic beds.

Andesite Sills Within the Fatima Formation

Six andesite sills are intruded in the Fatima Formation of J. Abu Ghurrah area. Each of the three members of the Fatima Formation is intruded by two of these sills. The two sills that are intruded in the lower Fatima member are thin (a few meters thick) and exist in the northeastern part of the area. They seem to pinch out laterally toward the southwest.

One of the two andesite sills that are intruded in the middle Fatima member is very thick and exists close to the top of this member. According to Nebert *et al.* (1974, p. 17) this sill is 150 meters thick. Detailed mapping during the present study indicates that the exact thickness of this sill can not be estimated in J. Abu Ghurrah area. This is related to the effect of thrust faults which affect at least one of the two contacts of the sill and, therefore, the exposed thickness is less than the total thickness of the sill.

This sill was never observed in the southeastern exposures of J. Abu Ghurrah and is thought to pinch out toward the southeast. The other andesite still that is intruded in the middle Fatima member is about two meters thick. It exists locally at the base of the member in the southwestern part of the area.

One of the two sills that are intruded in the upper Fatima member is located at the base of this member. The thickness of this sill is small (3-5 meters) and constant all over the mapped area. The other sill is thicker and exists near the middle part of the mapped section of the upper Fatima member. It is associated with contact metamorphism of the overlying and underlying siltstone beds.

Isotopic ages of the volcanics of the Fatima Formation indicate a Late Precambrian age. Duyverman *et al.* (1982) indicated a Rb/Sr whole rock age of 675 ± 17 m.y. whereas Darbyshire *et al.* (1983) indicated a Rb/Sr whole rock weighted mean age of 688 ± 30 m.y.

Geologic Setting

The J. Abu Ghurrah area can be divided into three subblocks called herein the northeastern (NE), central, and southwestern (SW) subblocks (Fig. 3). These three subblocks are separated from each other by diagonal-slip faults oriented nearly WNW to NW. The three subblocks are affected by a large ENE to NE plunging syncline in addition to a set of low-angle imbricate thrusts and a décollement fault (Figs. 3 and 4).

Common mesostructures in the NE and SW subblocks include mesofolds in addition to a few minor thrusts. Similar mesofolds affect the sedimentary rocks of the central subblock and lie close to the décollement and the thrust faults. Intra-bed structures in the form of mesofolds and minor thrusts represent layer-parallel shortening and are more abundant in the NE and SW subblocks than in the central subblock.

Mesostructures

Four different types of mesostructures were recognized in J. Abu Ghurrah area. These are mesofolds, minor thrusts, bedding plane slickenside striae, and minor strike-slip (tear) faults. The intensity of deformation by these mesostructures increases from the northwestern to the southeastern parts of the study area.

Mesofolds

Mesofolds mapped in the study area affect mainly the limestone and sandstone beds of the middle Fatima member and occasionally the siltstone and claystone beds of the lower Fatima member. These folds were never observed in the rocks of the upper Fatima member. A total of 149 mesofolds were measured in the field. Mesofolds of the central subblock exist above and/or below the thrust faults and below the décollement. The mapped mesofolds are asymmetric to overturned,

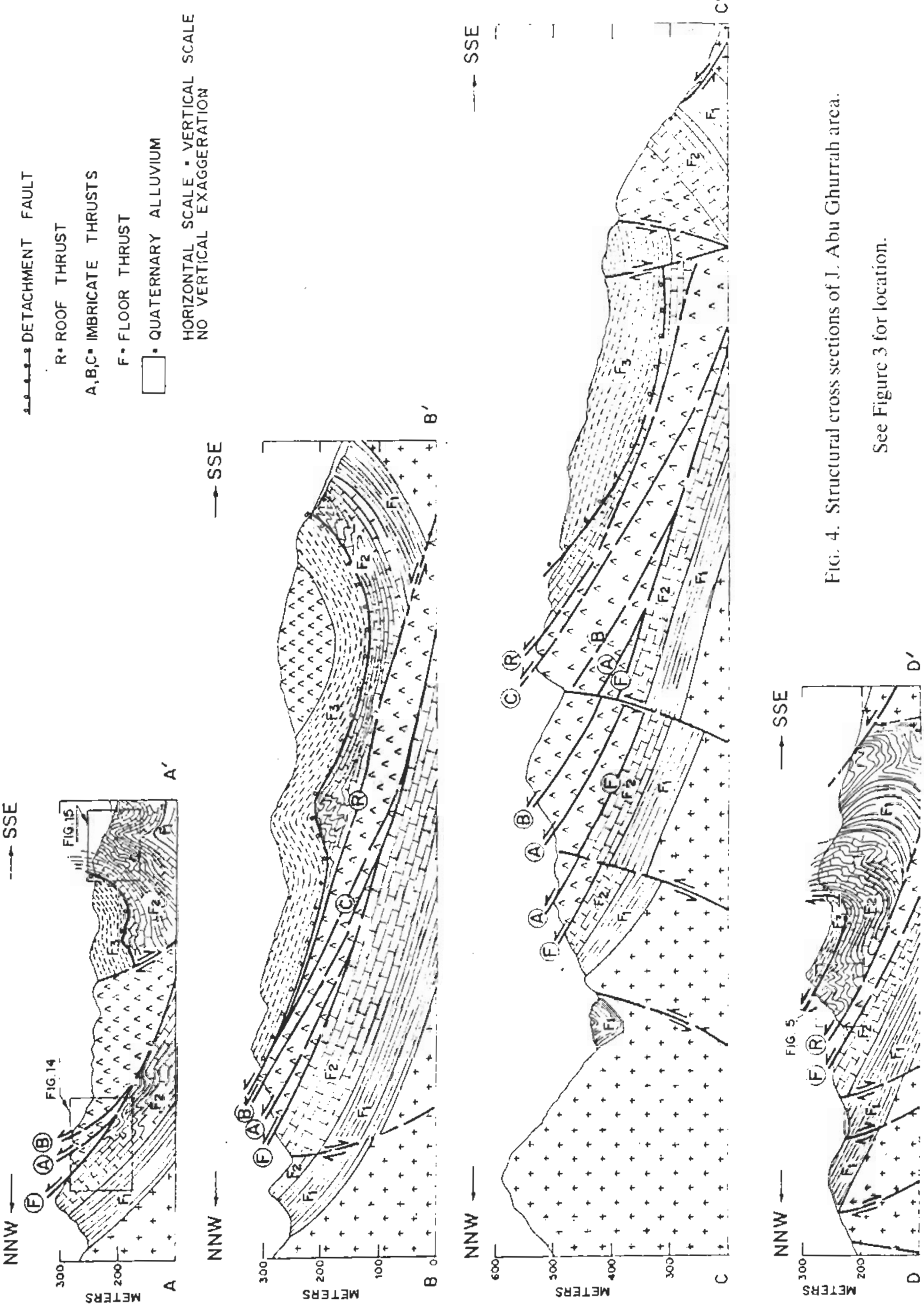


FIG. 4. Structural cross sections of J. Abu Ghurrah area.

See Figure 3 for location.

plunging, close to tight, and generally of a near chevron shape (Fig. 5). Some of the chevron folds in the middle Fatima member show bulbous hinges or limb thrusts (Ramsay 1974) when a relatively thick limestone bed exists within the thinner bedded folded sequence. In such cases, ductile siltstone and/or claystone beds flow into the hinge areas of the folds to fill the resulting gaps. Recumbent folds exist in the lowermost part of the middle Fatima member in the northwestern part of the SW subblock (Fig. 4, cross section D-D′). Folds mapped in the central subblock below the décollement fault are of the cuspate-lobate type (Davis 1984) and have a maximum plunge of 51° and an average plunge of 36°. Other mesofolds were found in the same subblock above the uppermost thrust fault and are generally box folds of the Jura type (Laubscher 1961), Fig. 6.

The mesofolds of J. Abu Ghurrah area have a mean trend of N71°E and a mean plunge equal to 35° (Fig. 7a). The axial surfaces of the mapped folds are inclined to the SE. A sample of these surfaces indicate that they are oriented N56°E and dip 74°SE (Fig. 7b).

Several intra-bed mesofolds representing layer-parallel shortening were mapped mainly in the SW subblock and sometimes in the NE subblock (Fig. 8).

Minor Thrusts

Minor thrusts were mapped mainly in the SW and NE subblocks and have displacements in the order of a few centimeters to several tens of centimeters. The attitudes of 19 such thrusts were measured and have a mean strike oriented N48°E and mean dip equal to 40°SW (Fig. 7c).

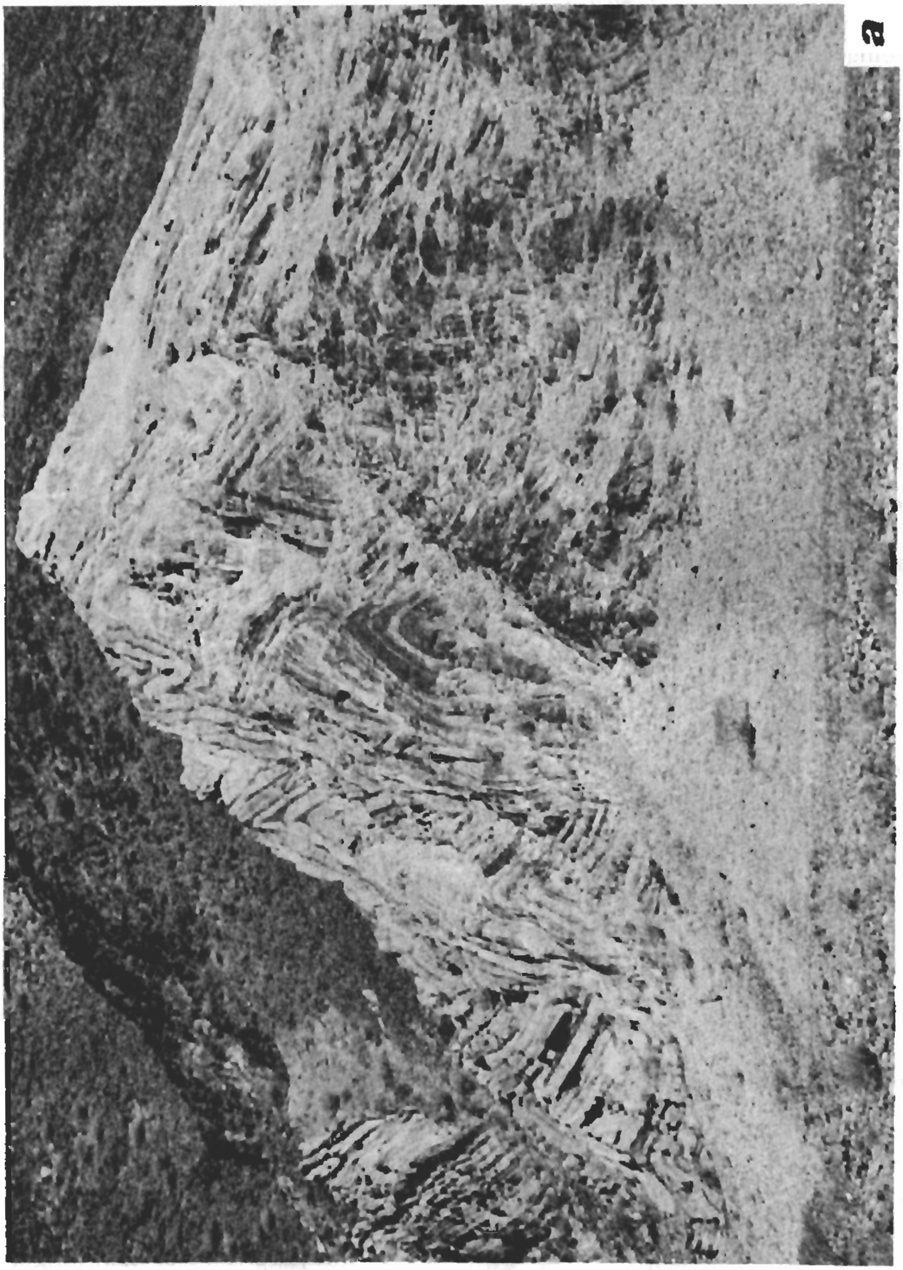
A set of minor imbricate thrusts was mapped in the overturned flank of the large syncline of the SW subblock. These thrusts form a hinterland dipping complex (Boyer and Elliot 1982), Fig. 9. These thrusts affect only the thick stromatolitic limestone bed indicating intra-formational shortening in the middle Fatima member.

Bedding Plane Slickenside Striae

Bedding plane slickenside striae are dominant in the study area and indicate layer-parallel slip during the deformation. The attitudes of 15 such slickenside lineations were measured in the field and their trends were found after their host beds were rotated to horizontal about their strikes. These slickenside striae have a mean orientation of N36°W-S36°E (Fig. 7d).

Minor Tear Faults

Several mesoscopic tear faults affect the steep southeastern flank of the overturned syncline of the SW subblock. These faults exist mainly in two conjugate sets oriented N-S and NNW-SSE (Figs. 3 and 7e). Fault plane slickenside striae indicate that these faults are strike-slip and/or diagonal-slip. Some of these faults were examined for determining the orientations of the principal stress axes following the procedures of Angelier (1979 and 1984) and Michael (1984). Two of these samples are shown in Fig. 10 together with the determined principal stress axes.


a

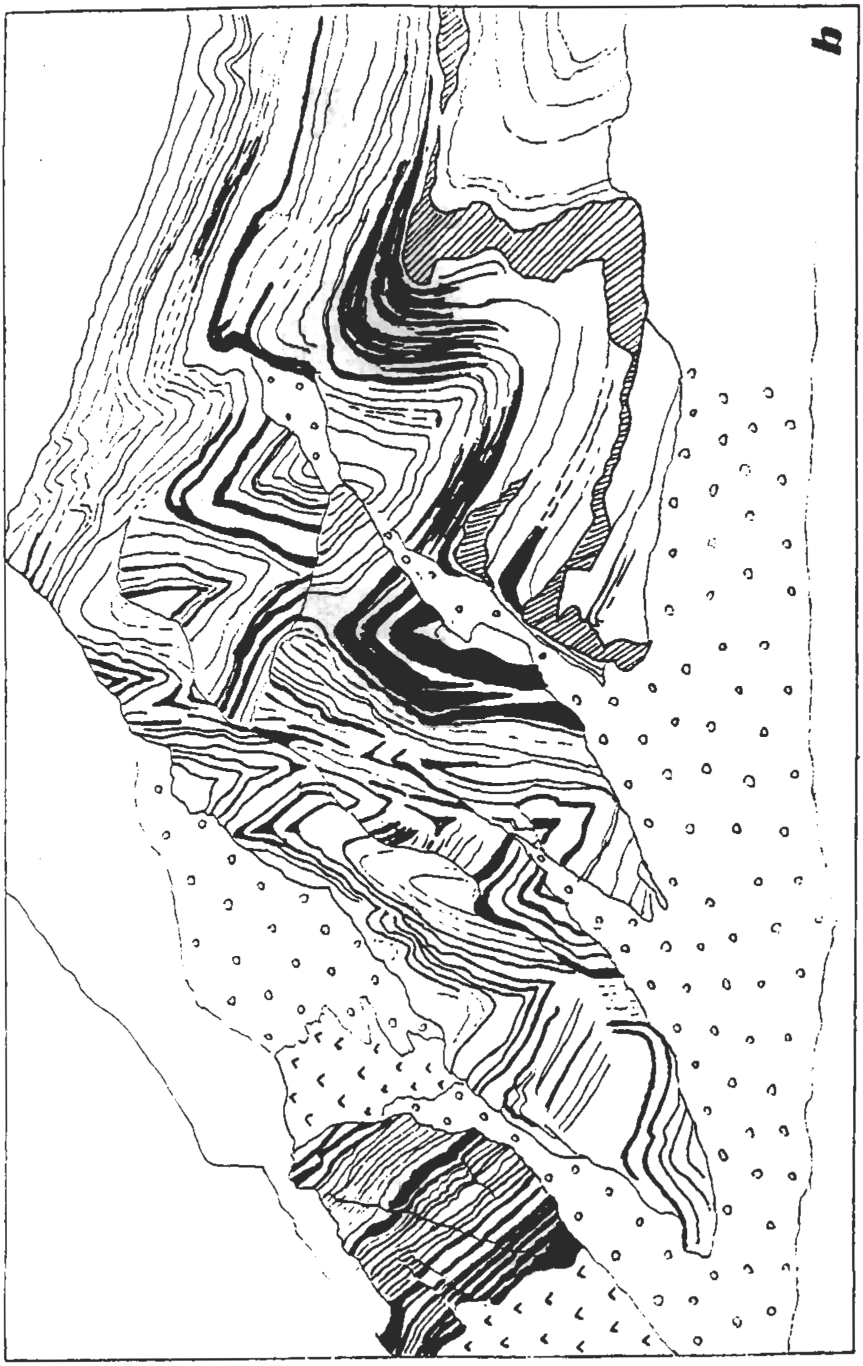


FIG. 5. Field photograph (a) and sketch (b) of a group of close to tight, asymmetric to overturned folds of a near chevron shape affecting the middle Fatima member in the northwestern side of the SW sub-block. See Figure 4 (cross section D-D') for location.

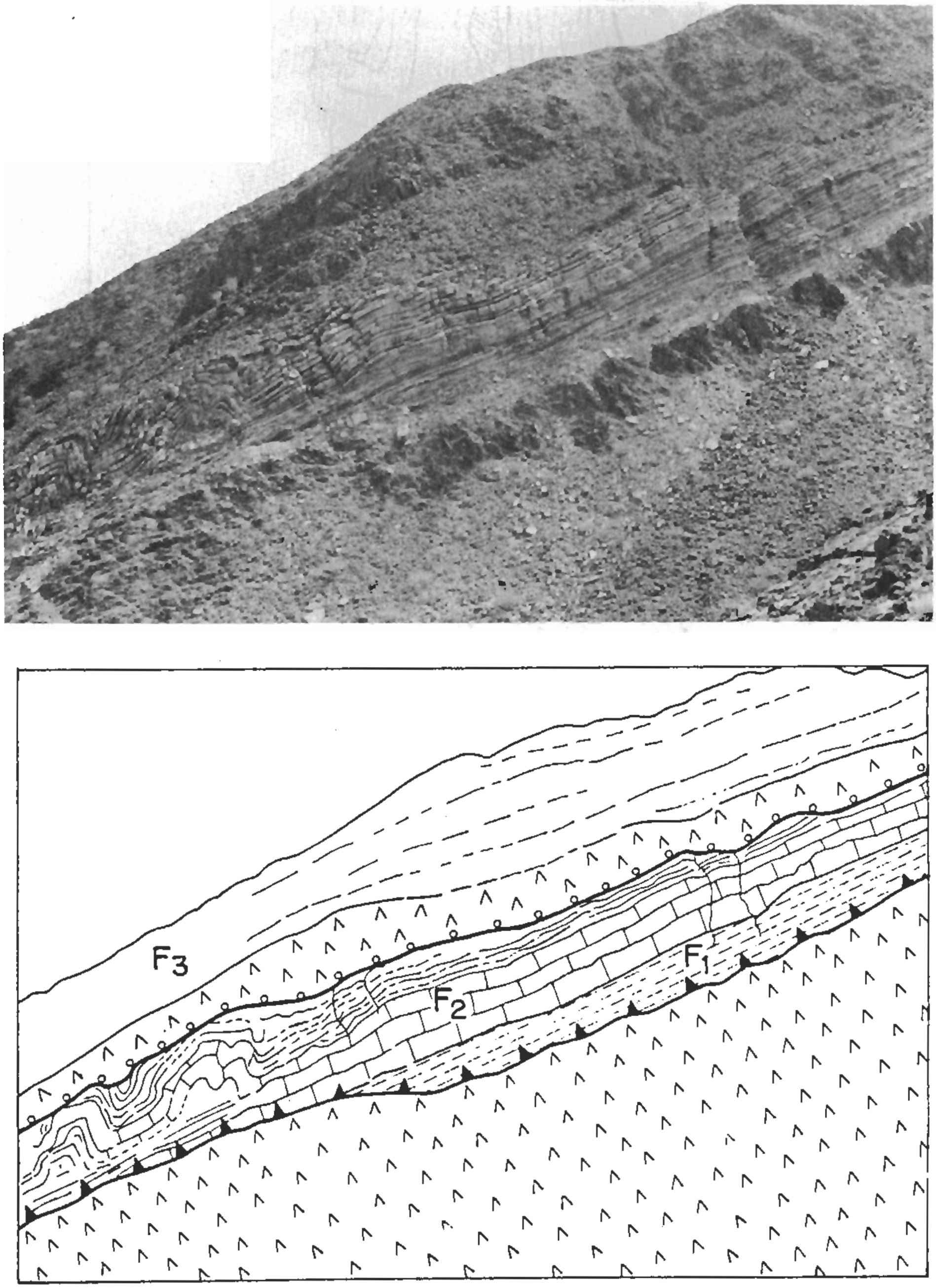


FIG. 6. Box folds in the middle Fatima member (F2) above the roof thrust of J. Abu Ghurrah duplex.

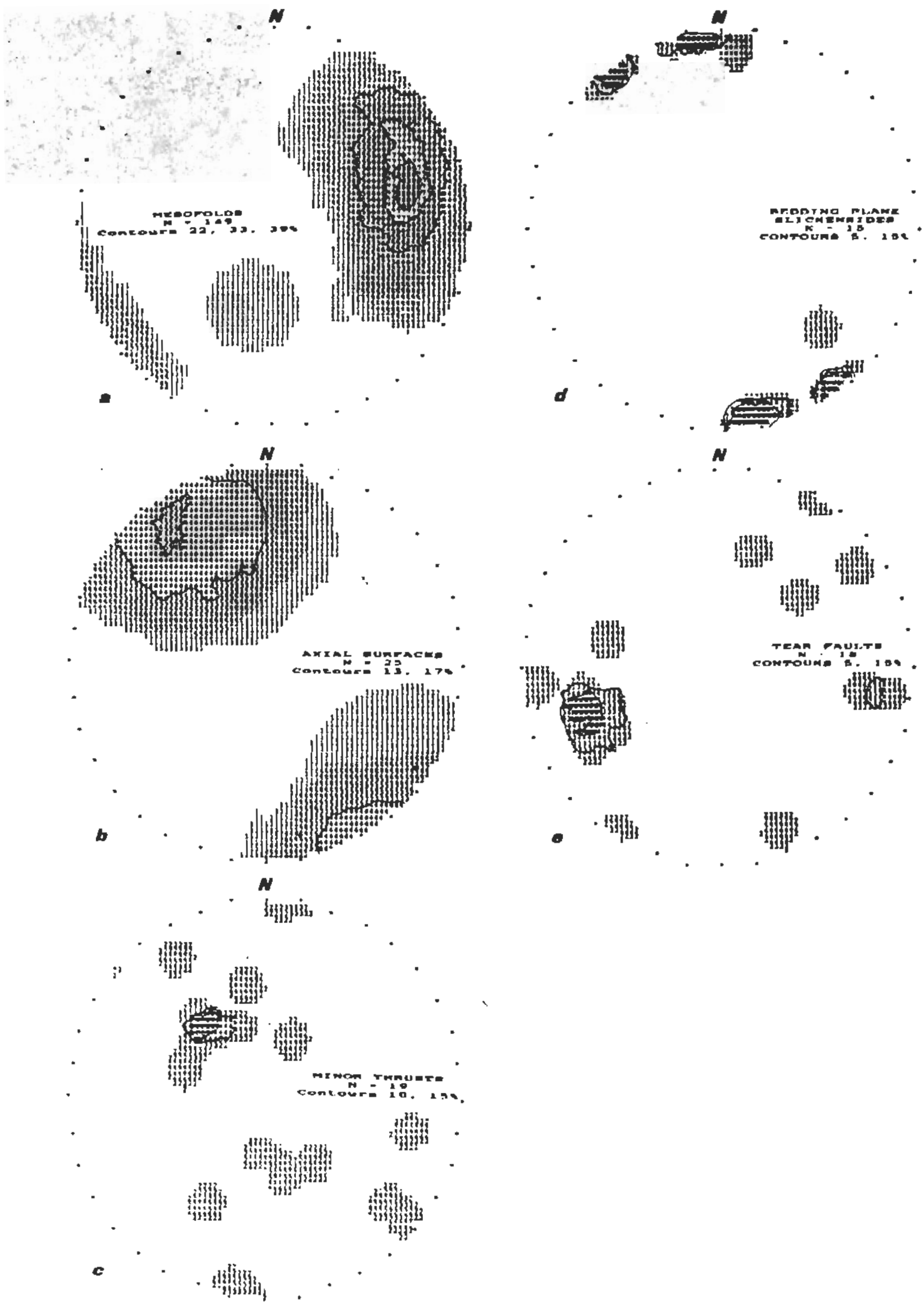


FIG. 7. Lower hemisphere, equal area contour diagrams of the mesostructures of J. Abu Ghurrah area.

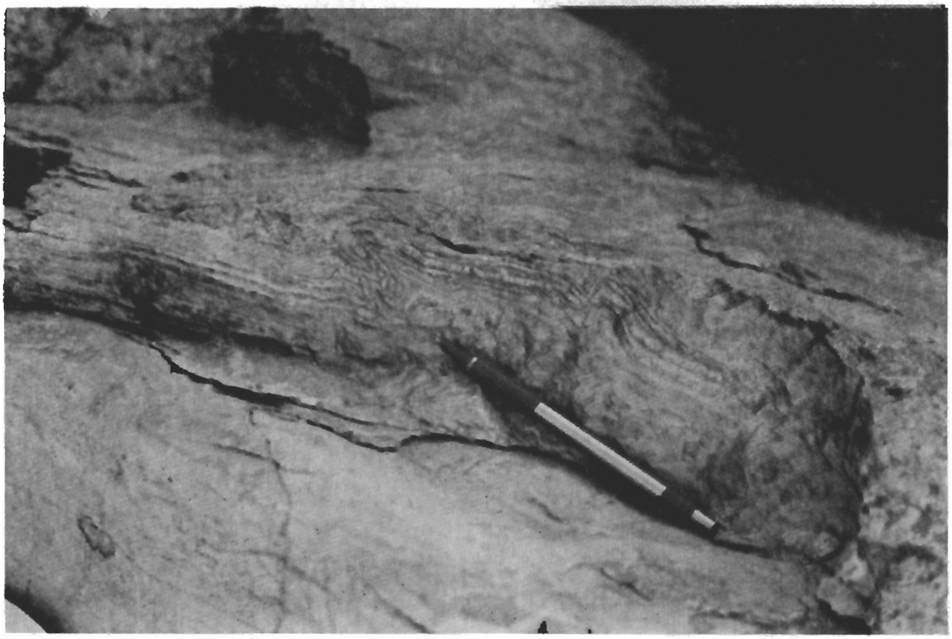


FIG. 8. Layer-parallel shortening in the middle Fatima member in the SW subblock of J. Abu Ghurrah.

Strain Analysis of Mesostructures

The direction of maximum shortening in the J. Abu Ghurrah area has been determined from the orientations of the mesostructures discussed above. The direction of maximum shortening (and possibly the greatest principal stress axis) is normal to both the axial planes of mesofolds and the fold axes within the axial planes (Turner and Weiss 1963, p. 524). The direction of maximum shortening is also considered parallel to the trend of the bedding plane slickenside which are normal to the fold axes and parallel to the direction of tectonic transport. Minor thrusts, on the other hand, make an angle of about 30° to the direction of maximum shortening or σ_1 (Billings 1972). The results of strain analysis of the different mesostructures are shown in Fig. 11. These results indicate that J. Abu Ghurrah area was shortened in the NNW-SSE direction.

Macrostructures

Macrostructures mapped in J. Abu Ghurrah area are in the form of folds, detachment faults, a décollement associated by a set of low angle imbricate thrusts, and diagonal-slip and normal faults (Figs. 3 and 4). A detailed description of each of these macrostructures is given in the following sections.

Macrofolds

The structure of J. Abu Ghurrah area has the form of a large, NE plunging, over-

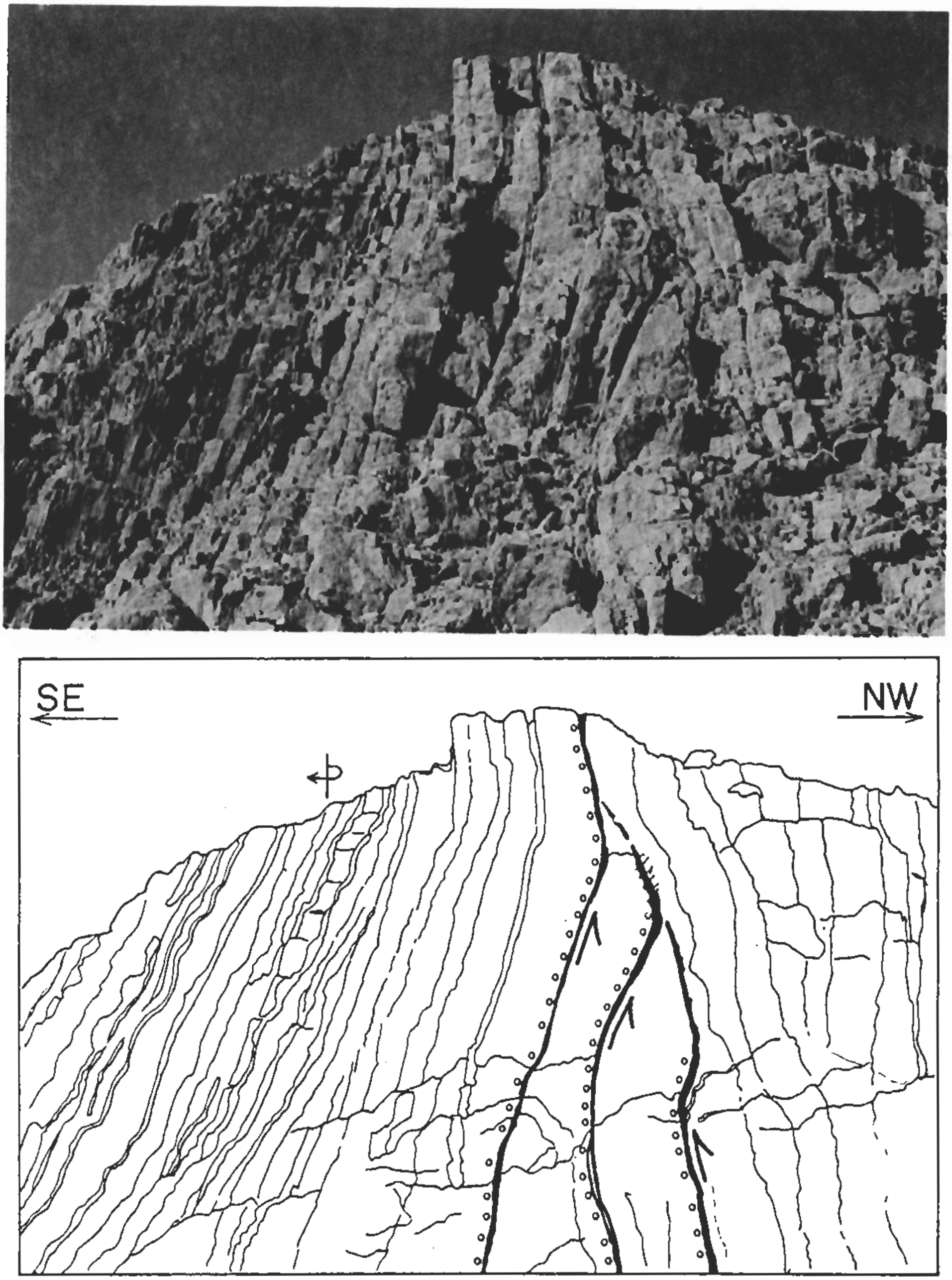


FIG. 9. Field photograph and sketch of a minor thrust duplex (now hinterland dipping) affecting the thick, overturned to steeply dipping stromatolitic limestone bed of the middle Fatima member in the SW subblock.

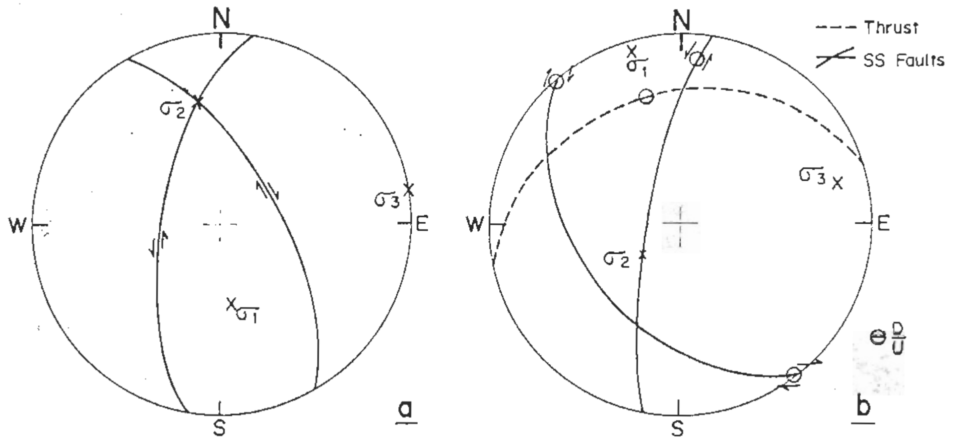


FIG. 10. Principal stress axes determined from slickenside striae of two samples of minor tear faults from the SW subblock. a) Two strike-slip faults. b) Two diagonal-slip faults and an accompanying thrust fault.

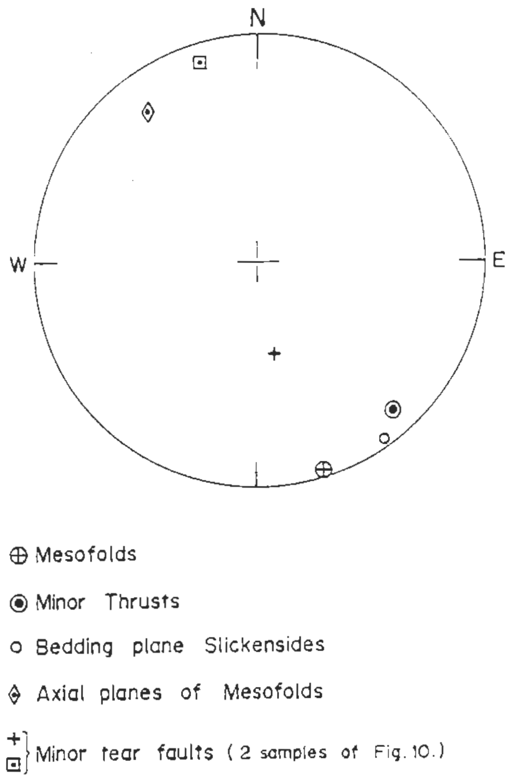


FIG. 11. Direction of maximum shortening as indicated by the mesostructures of J. Abu Ghurrah area.

turned syncline which is dissected by faults in several places. An overturned syncline is mapped in each of the SW and central subblocks whereas the syncline mapped in the NE subblock is asymmetric (Fig. 3). It is believed that the asymmetric syncline of the NE subblock was originally overturned but was later affected by erosion leading to the removal of a large portion of the southeastern flank and hence the overturned beds.

Two other folds (a syncline and an anticline) are mapped in the northeastern part of the central subblock (Fig. 3). They have relatively smaller dimensions compared to the large overturned syncline mentioned above.

The overturned syncline of the SW subblock gently plunges in the ENE direction and has an axial surface dipping at an angle of about 30°SSE (Figs. 3; 4, cross section D-D′; and 12). The southeastern flank of this syncline is overturned and affected by several tear faults oriented N-S to NNW (Fig. 3). The sandstone and limestone beds of the middle Fatima member in the two flanks of this fold are affected by several mesofolds (Fig. 12). The mesofolds affecting the northwestern flank of the syncline exceed in number those in the southeastern flank and are overturned at the contact with the underlying thrust (Figs. 12 and 13). The brittle, slightly metamorphosed siltstone and sandstone beds of the upper Fatima member which occupy the trough of the syncline are not affected by mesofolds but were detached out of the trough of the syncline (Fig. 12).

The syncline affecting the NE subblock of J. Abu Ghurrah area is asymmetric and gently plunges in the ENE direction. The northwestern flank of this syncline is affected by several tear faults oriented N-S and NNW-SSE to NW-SE (Fig. 3). The two flanks of the syncline are affected by mesofolds which have vergence directions pointing away from the synclinal trough (Fig. 4, cross section A-A′). NNW vergent mesofolds in the northwestern flank of the syncline were probably formed by movement on the overlying décollement (Fig. 14 and cross section A-A′ of Fig. 4) whereas the mesofolds of the southeastern flank are SSE vergent (Fig. 15).

The overturned syncline of the central subblock is oriented N43°E-S43°W and its axial surface dips to the southeast. At the southwestern side of the central subblock, the syncline is not overturned but is nearly symmetrical and oriented N60°E-S60°W (Fig. 4, cross section C-C′).

Detachment Faults

The slightly metamorphosed brittle siltstone and sandstone beds of the upper Fatima member occupy the trough of the large syncline in the three subblocks of J. Abu Ghurrah area. In contrast to the underlying limestone beds of the middle Fatima member, these brittle rocks are not affected by mesofolds. The brittleness of the rocks of the upper Fatima member is perhaps related to their metamorphic nature. This brittle section was detached from the underlying limestone beds during the development of the large syncline of the area. With continued folding, the detached section has moved out of the trough of the syncline (Fig. 12). The surface of detach-

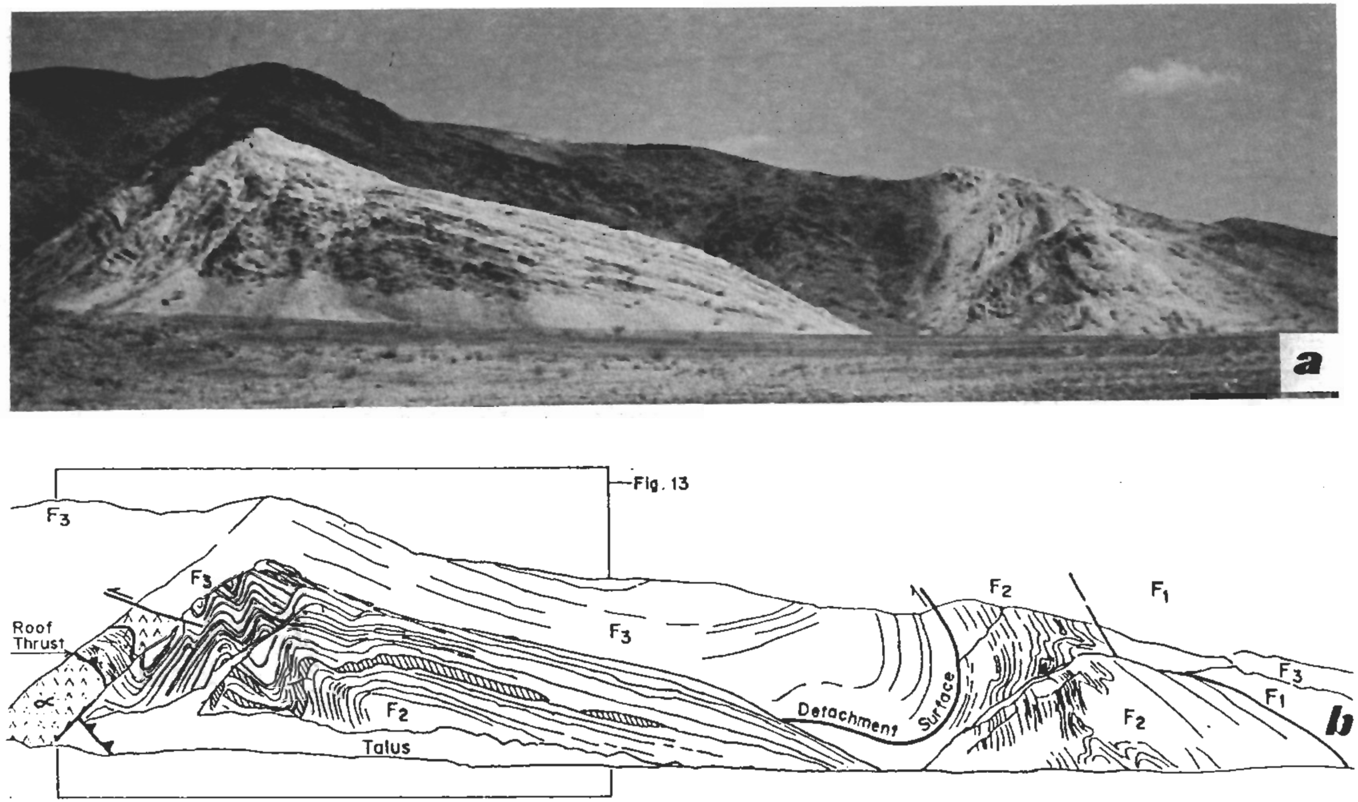


FIG. 12. Field photograph (a) and sketch (b) of the overturned syncline of the SW subblock. Notice the abundant mesofolds in the middle Fatima (F2) member (especially the NNW flank above the roof thrust) and their absence in the upper Fatima member (F3). The latter is detached out of the trough of the syncline. F1 and α designate the lower Fatima member and the thick andesite sill of the middle Fatima member respectively.

FIG. 13. Close-up view of the NNW flank of the syncline of Figure 12 showing the overturned folds at the base of the middle Fatima member due to its thrusting over the thick andesite sill.

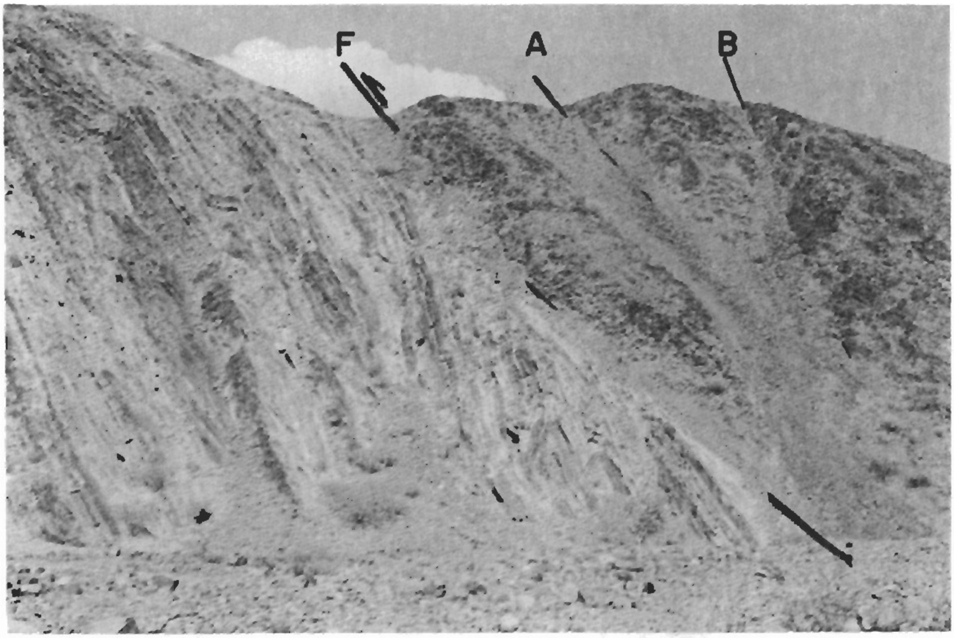


FIG. 14. A décollement (F) between the thick andesite sill and the limestone beds of the middle Fatima member in the NE subblock. NNW vergent mesofolds affecting the limestone beds were formed by the movement on the décollement. Two thrusts (A and B) are also indicated and cause the repetition of the sill. See Figure 4 (cross section A-A′) for location.

ment has been mapped in the area as shown in Figs. 3 and 4. The term detachment fault was used in the present study refers to a layer-parallel surface on which a brittle rock unit is forced to move, during folding, in the updip directions away from the synclinal trough. In this way, our usage of the term is different from that of Billings (1972). Billings (1972, p. 196) defines a detachment fault as a low-angle normal fault related to downhill sliding of rocks from an uplifted region.

Décollement Fault

A décollement exists between the thick andesite sill of the middle Fatima member and the underlying competent limestone beds. It is parallel to bedding and is a zone of simple shear indicating updip movement of the sill (*i.e.* thrust slip). NNW vergent, overturned folds were formed in the underlying limestone beds due to the shearing on the décollement. This décollement is called herein the floor thrusts and is exposed in the northwestern sides of the NE and central subblocks. It is not obvious in the SW subblock where it is either absent or concealed in the subsurface.

The décollement is well exposed in the NE subblock and is marked by a highly foliated and intensely lineated shear zone (Figs. 3 and 14). Mesofolds affecting the competent beds of the middle Fatima member below the décollement indicate thrust

FIG. 15. SSE vergent, overturned mesofolds in the middle Fatima member in the NE subblock. See Figure 4 (cross section A-A′) for location.

slip on the décollement in the NNW direction. Slickenside lineations in the shear zone (Fig. 3) indicate the same sense of movement.

The décollement is also well exposed in the central subblock where the beds that underlie the décollement and belong to the middle Fatima member and the top part of the lower Fatima member are highly deformed by mesofolds. These folds have relatively steep plunges (Fig. 3) that reach 51° and have a cuspate-lobate pattern (Davis 1984). They have NNW vergence and indicate a NNW sense of movement on the décollement.

Low-Angle Thrusts

A set of five low-angle imbricate thrusts exists in J. Abu Ghurrah area. These thrusts dip in the southeast direction at an angle of 32° or less (Figs. 16 and 17). On the hanging wall of the topmost one of these thrusts, the pre-Fatima granites are thrusted over the lowermost part of the Fatima Formation (Fig. 3; Fig. 4, cross section D-D'; and Fig. 16). This thrust crops out in the SW subblock and partly in the central subblock. The other four thrusts are well exposed in the central subblock. Only two of these thrusts crops out in the NE subblock. The four thrusts are given the symbols A, B, C, and R from base to top. Thrust R is parallel to bedding and causes the topmost part of the lower Fatima member and the overlying section of the middle and upper Fatima members to ride over the thick andesite sill of the middle Fatima member (Fig. 3 and Fig. 4, cross sections B-B' and C-C'). Thrusts A, B, and C are imbricate and affect the thick andesite sill of the middle Fatima member causing its repetition for several times (Figs. 3 and 17).

The thrust fault that is exposed in the SW subblock represents the southwestern continuation of thrust R. Two thrusts are exposed in the NE subblock above the décollement and most probably represent the northeastern continuation of thrusts A and B (Fig. 14).

The décollement and the four thrusts, A, B, C, and R perhaps form a hinterland dipping thrust duplex (Boyer and Elliot 1982) that is called herein Abu Ghurrah Duplex (AGD; Fig. 4, cross sections B-B' and C-C'). The décollement represents the floor (sole) thrust of the duplex whereas thrust R represents the roof thrust. The three imbricate thrusts A, B, and C lie within the duplex and perhaps sole into the décollement.

Displacement on the roof thrust of AGD is most probably very large. On the hanging wall of this thrust, the thick andesite sill is missing from the top part of the middle Fatima member. The allochthonous rocks of this thrust sheet were perhaps transported for a long distance from an area farther southeast from where the sill is assumed to have pinched out.

Diagonal-Slip and Normal Faults

Diagonal-slip and normal macrofaults form two conjugate sets oriented WNW to

FIG. 16. Granites of the pre-Fatima basement overriding the lower Fatima member by a low-angle thrust dipping 32°SE at the southeastern side of the SW subblock.

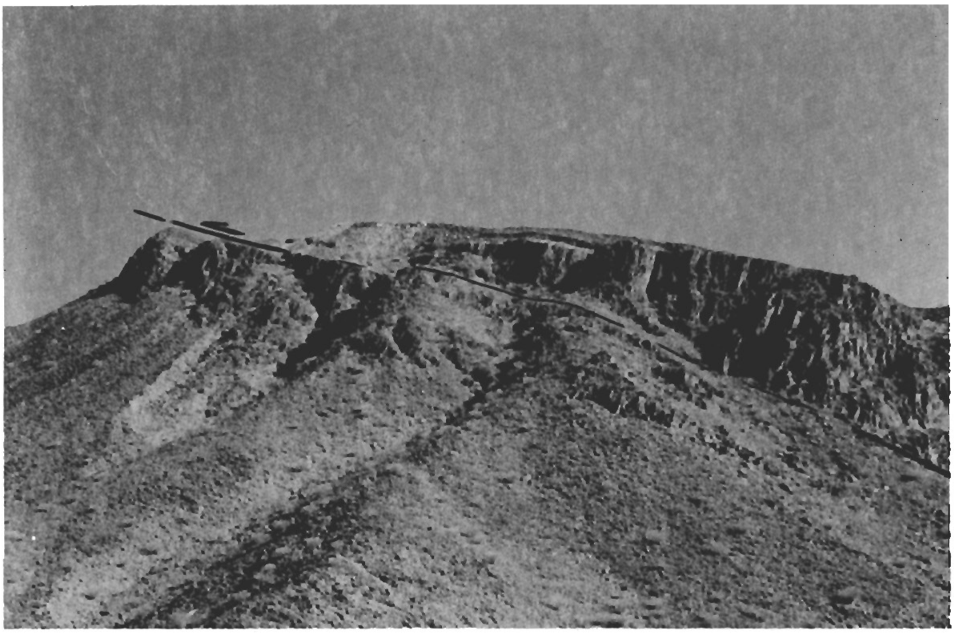


FIG. 17. Repetition of the thick andesite sill of the middle Fatima member by a low-angle thrust in the northwestern side of the central subblock.

WSW with a mean E-W orientation and NNW-SSE (Figs. 3 and 18). Slickensides were observed on only two of these faults and indicate diagonal-slip movement. The first of these faults is oriented ENE-WSW and is right-lateral normal whereas the

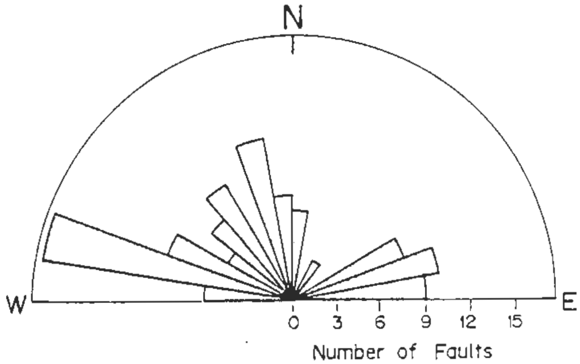


FIG. 18. Rose diagram of 109 macrofaults shown in Figure 3 (excluding thrust faults).

second fault is oriented NNW-SSE and is left-lateral reverse (Figs. 3 and 19). The slickenside striae of these two faults indicate the following orientations of the principal stress axes (Fig. 19) :

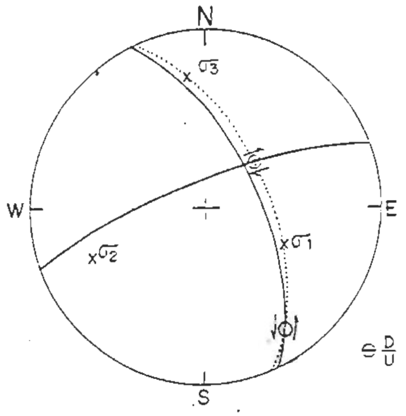


FIG. 19. Principal stress axes determined from slickenside striae (small circles) of two diagonal-slip macrofaults (solid arcs) in the area. Dotted arc represents the σ_1-σ_3 plane.

σ_1 : 49°/N114°
σ_2 : 30°/N247°
σ_3 : 25°/N351°

Structural Synthesis

Detailed analysis of the meso- and macrostructures of J. Abu Ghurrah area indicates that the area was affected by NNW-SSE tangential compression after the deposition of the uppermost Precambrian sediments of the Fatima Formation and the intrusion of the accompanying andesite sills. The direction of tectonic transport is toward the NNW. The intensity of deformation increases from the northwest to the southeast.

The strutural styles in the area are represented by synclinal folding and low-angle thrusting. Folding is of the flexurial-slip type (Ramberg 1970) evidenced by the presence of layer-parallel slip. Folding is accompanied by out-of-the-syncline detachment of brittle rocks represented by the upper Fatima member. Low-angle and bedding thrusts led to the development of a hinterland dipping duplex.

The sequence of events in the study area indicates that the first deformation proceeded by layer-parallel shortening leading to the development of intra-bed folds and thrusts. In the second event, the area was deformed by an ENE to NE plunging, overturned syncline (Fig. 20a). During the third structural event, continued deformation of the area by the same tangential compression was evident and led to the development of low-angle thrusts. The thick andesite sill at the top of the middle Fatima member acted like a brittle and rigid beam which resisted folding and failed by low-angle thrusting leading to the development of the J. Abu Ghurrah complex (Fig. 20b). Diagonal-slip and normal fault were formed in two sets oriented WNW to WSW and NNW during the fourth structural event and caused the offset of some of the thrust faults (Fig. 20c).

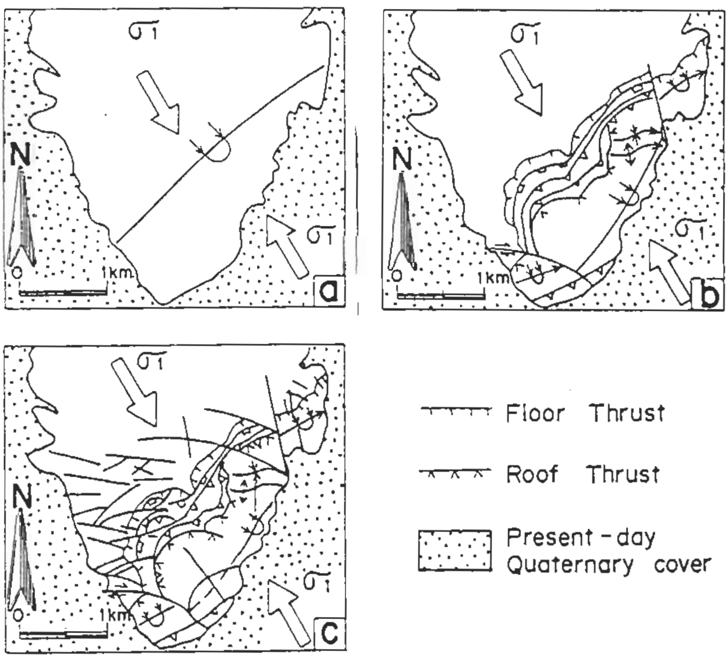


FIG. 20. Sequence of structural events in J. Abu Ghurrah area following the first event of layer-parallel shortening. See text for details and Figure 3 for symbols. σ_1 designates the maximum principal stress axis.

References

Angelier, J. (1979) Determination of the mean principal directions of stress for a given fault population, *Tectonophysics,* **56:** T17-T26.

Angelier, J. (1984) Tectonic analysis of fault slip data sets, *Jour. Geophys. Res.* **89:** 5835-5848.

Billings, M.P. (1972) *Structural geology,* 3rd edition, Prentice-Hall, Inc., New Jersey, 606 p.

Boyer, S.E. and **Elliot, D.** (1982) Thrust systems, *AAPG Bull.* **66:** 1196-1230.

Brown, G.F. and **Jackson, R.O.** (1960) The Arabian Shield, *21st Internat. Geol. Congr.,* Copenhagen, pt. 9, pp. 69-77.

Darbyshire, D.P.F., Jackson, N.J., Ramsay, C.R. and **Roobol, M.J.** (1983) Rb-Sr isotope study of latest Proterozoic volcano-sedimentary belts in the central Arabian Shield, *J. Geol. Soc. London,* **140:** 203-213.

Davis, G.H. (1984) *Structural geology of rocks and regions,* John Wiley and Sons, Inc., New York, 492 p.

Duyverman, H.J., Harria, N.B.W and **Hawkesworth, C.J.** (1982) Crustal accretion in the Pan African: Nd and Sr isotope evidence from the Arabian Shield, *Earth and Planet. Sci. Lett.,* **59:** 315-326.

Karpoff, R. (1955) Observations preliminaries sur le socle ancien de l'Arabie, *C.R. Somm. Geol. Soc. Fr.,* 105-106.

Laubscher, H.P. (1961) Die Fernschubhypothese der Jurafaltung, *Eclog. Geol. Helv.* **54:** 221-282.

Michael, A.J. (1984) Determination of stress from slip data: faults and folds, *Jour. Geophys. Res.* **89:** 11517-11526.

Moore, T.A. and **Al-Rehaili, M.H.** (1989) Explanatory notes to the geologic map of the Makkah Quadrangle, sheet 21-D, *Geoscience* **Map GM-107C,** *Kingdom of Saudi Arabia, Ministry of Petroleum and Mineral Resources, Directorate General of Mineral Resources,* 62 p.

Nebert, K., Alshaibi, A.A., Awlia, M., Bounny, I., Nawab, Z.A., Sharief, O.H., Sherbini, O.A. and **Yeslam, A.H.** (1974) Geology of the area north of Wadi Fatima, Kingdom of Saudi Arabia, *Center for Applied Geology, Jeddah, Bull.* no. **1:** 31 p.

Ramberg, H. (1970) Folding of laterally compressed multilayers in the field of gravity, *I: Physics of Earth and Planetary Interiors,* **2:** 203-232.

Ramsay, J.G. (1974) Development of chevron folds, *Geol. Soc. Amer. Bull.* **85:** 1741-1754.

Turner, F.J. and **Weiss, L.E.** (1963) *Structural analysis of metamorphic tectonites,* McGraw-Hill Book Co., New York, 545 p.

الوضع التركيبي لمنطقة جبل أبوغرة ، وادي فاطمة ، غرب وسط المملكة العربية السعودية

فواز عبد الرحمن ذاكر و عادل رمضان مصطفى
كلية علوم الأرض ، جامعة الملك عبد العزيز ، جـدة ، المملكة العربية السعودية

المستخلص . توضح الدراسة الحقلية التفصيلية للتراكيب الجيولوجية بمنطقة جبل أبوغرة أن الصخور الرسوبية والبركانية المتكونة في الفترة الأخيرة من عصر ما قبل الكامبري قد تشوهت بقوى مماسة اتجاهها شمال شمال غرب - جنوب جنوب شرق . وتشمل نظم التشوه المتكونة : الطي الانحنائي المنزلق الذي أدى إلى تكوين طيه مقعرة غاطسة كبيرة مقلوبة اتجاهها شرق شمال شرق إلى شمال شرق بالإضافة إلى صدوع دسر قليلة الميل في مزدوج دسري يميل ناحية الجنوب جنوب شرق . والصدع السفلي لهذا المزدوج عبارة عن سطح انفصال بين سد سميك جدا من الأنديزيت والصخور الجيرية الواقعة تحته والتي تتبع العضو الأوسط لتكوين الفاطمة . أما عن الصدع العلوي للمزدوج فله أكبر إزاحة ضمن صدوع الدسر بالمنطقة . ويعتقد أن هذا المزدوج قد تكون نتيجة القصر المستمر في المنطقة حيث سلك سد الأنديزيت السميك سلوك المواد القصمة الجامدة فقاوم الطي وتقطع بصدوع الدسر قليلة الميل .

ويمثل القصر الموازي لأسطح التطبق المرحلة الأولى للتشوه بالمنطقة والتي أدت إلى تكوين طيات وصدوع دسر صغيرة .