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Journal of African Earth Sciences, Vol. 6, No. 1, pp. 19–27, 1987
Printed in Great Britain

0731-7247/87 $3.00 + 0.000
Pergamon Journals Ltd.

Tectonometamorphic evolution of the gneissic Kidal assemblage related to the Pan-African thrust tectonics (Adrar des Iforas, Mali)

M. CHAMPENOIS*, A. M. BOULLIER*, V. SAUTTER†, L. I. WRIGHT‡ and P. BARBEY*§

* C.R.P.G., C.N.R.S., BP 20, 54501 Vandoeuvre Les Nancy Cedex, France
† Laboratoire de Minéralogie, Museum d'Histoire Naturelle, 61, rue Buffon, 75005 Paris, France (Nouvelle adresse: Laboratoire de Physique du solide, Université d'Orsay, Bat. 510, 91405 Orsay Cedex, France)
‡ Department of Earth Sciences, The University, Leeds LS2 9JT, U.K.
§ Laboratoire de Pétrologie, Université de Nancy I, 54500 Vandoeuvre Les Nancy Cedex, France

(*Received for publication* 1 *April* 1986)

Abstract—In the central part of the Adrar des Iforas (Mali), the 2 Ba Eburnean granulitic unit has been thrust above a high-grade gneissic unit, the so-called 'Kidal assemblage', during an early event of the Pan-African orogeny. The Kidal assemblage can be defined as a tectonic mixing of an Eburnean granulitic basement, its sedimentary cover of Middle to Upper Proterozoic age (quartzites, marbles, basalts and metavolcanics) and various pretectonic rocks: ultrabasic to basic rocks, diorites, tonalites. All these rocks have been deformed during at least four main events and metamorphosed together. Thrusting of the Iforas Granulitic Unit above the Kidal assemblage happened during the first event D1. The movement direction was roughly N–S, as shown by the stretching lineation. Some field criteria indicate a sense of displacement towards the north. The lattice preferred orientation of quartz c- and ⟨a⟩ axes indicate that the slip was dominantly on prismatic and probably pyramidal planes along an ⟨a⟩ direction; consequently D1 deformation was achieved at high temperature or low-strain rate. The quartz c- and ⟨a⟩ axes do not show any constant asymmetry, so they do not indicate a sense of shear. Two metamorphic stages have been found in the Kidal assemblage: the first one is characterized by kyanite in aluminous metasediments and by the occurrence of garnet–clinopyroxene-bearing boudins of basic rocks. The *P–T* range of this event is located at 700 ± 50°C and around 10 Kb. The second event is a syntectonic high temperature (600–650°C)–low pressure (3.5 Kb) stage accompanied by migmatization. Such a tangential deformation in barrowian-type metamorphic conditions and with N–S transport direction is known along the entire Trans–Saharan belt and cannot be related in a simple way to the collision between West African Craton and the mobile belt.

INTRODUCTION

THE Trans-Saharan belt (Cahen *et al.* 1984) is interpreted as the result of a collision between the passive margin of the West African Craton and the active margin of the Pan-African mobile belt, *ca* 600 Ma ago (Black *et al.* 1979). In the central Adrar des Iforas (Mali), four main Pan-African phases of deformation have been determined (Wright 1979, Boullier 1979, 1982, Davison 1980, Ball 1980), three of them (D2, D3, D4) being clearly related to the collision with the West African Craton. The first event (D1) corresponds to a deformation during which the granulitic Eburnean basement (the Iforas Granulitic Unit) and its Upper Proterozoic cover were thrust over a high-grade gneissic unit, the so-called Kidal assemblage (Boullier *et al.* 1978). The purpose of this paper is to describe lithology, structure and metamorphism of the Kidal assemblage related to that first event of deformation, and to study the kinematics of the thrust tectonics.

DEFINITION AND LITHOLOGY OF THE KIDAL ASSEMBLAGE

The Kidal assemblage has been defined by Boullier *et al.* (1978). It corresponds to a part of the 'Suggarian' mapped by Karpoff (1961) in the Adrar des Iforas. It is the result of a barrowian type tectonometamorphic evolution of various lithologic units of different ages which have been deformed together during D1 deformation (Fig. 1):

(i) Basement probably made of Eburnean granulites identical to In Ouzzal, In Bezzeg and Iforas Granulitic Units.

(ii) Sedimentary cover; on the west, these sediments (quartzites, schists and marbles) are overlain by basaltic flows with tholeiitic affinities (Leterrier and Bertrand 1986) and are probably Upper Proterozoic in age by comparison with NW Hoggar (Caby 1970). In the south-eastern Iforas (Tin Essako area, Davison 1980) and on the northern border of the Iforas Granulitic Unit (Tin Elor, Fig. 2), the thick quartzite sequence with interlayered alkaline metavolcanic and plutonic rocks is of Middle Proterozoic age (Caby and Andreopoulos-Renaud 1983).

(iii) Pre-tectonic intrusive rocks ranging from ultrabasites to gabbros and anorthosites with tholeiitic affinities and the same chemical characteristics as the basaltic lava flows cited above.

(iv) Pre-tectonic subalkaline metadiorites and metatonalites which in some places constitute the major part of the Kidal assemblage.

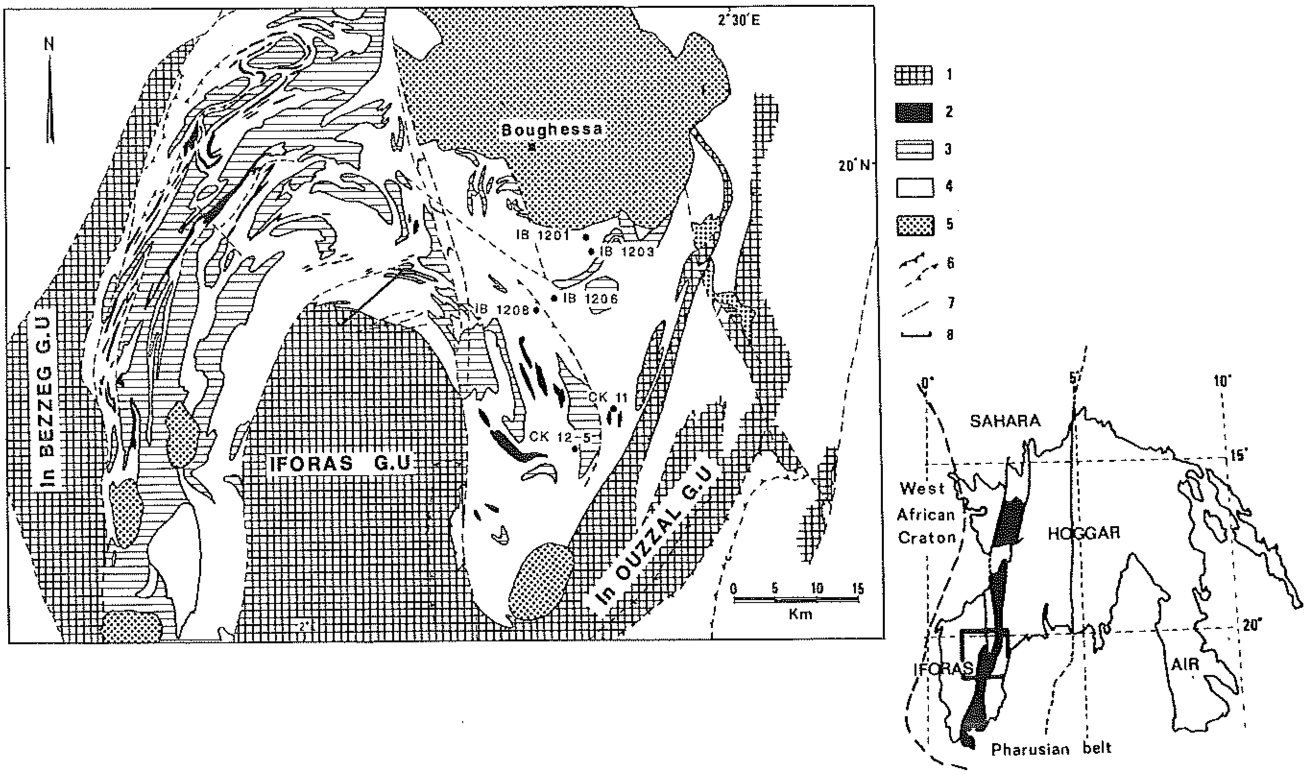

Fig. 1. Simplified geological map of northern part of Central Iforas and localization of samples used for structural study. 1, Eburnean granulites. 2, Mafic and ultramafic rocks. 3, Dioritic and tonalitic pre-tectonic intrusives. 4, Gneisses and metasediments (2–3–4 = Kidal assemblage). 5, Post-tectonic intrusives. 6, Thrusts. 7, Faults. 8, Localization of the section described in Fig. 2.

All these rock types show a strong deformation and a well defined metamorphic foliation. Considering this aspect and the large lithological variety, the gneissic Kidal assemblage is comparable to the Archean Gneiss Complex in the Gothab district and Saglek Fjord in Labrador (Bridgwater *et al.* 1978).

Only a few geochronological data are available on the different lithological units constituting the Kidal assemblage. By comparison, we may assume an age of 2120 Ma for the granulitic metamorphism of the basement (Lancelot *et al.* 1983) and attribute an age of 1837 Ma to the alkaline metarhyolites interlayered within the Middle Proterozoic quartzite sequence.

FIELD OBSERVATIONS

The structures in the Kidal assemblage are the result of the superimposition of all the Pan-African tectonic events. In some places (along the western margin of the Iforas Granulitic Unit), the latest ductile D3 event tends to obliterate all the previous structures. Keeping in mind the principal purpose of this study, that is the knowledge of the D1 event, this work has been focused on the north and northeast of the Iforas Granulitic Unit, where the structures related to D1 are still recognizable in large areas.

This region is divided into two parts by the Andjour–Tamaradant fault which is pro-parte a D3 dextral fault with a probable later activity (folded Ordovician towards the south, Karpoff 1961). If the displacement along this fault (about 25 km) is removed, the geological structures are in continuity. The gravimetric map shows that no contrast exists between the Kidal assemblage and the Iforas Granulitic Unit (Ly 1979); this fact is in accordance with the allochthonous interpretation for the granulites.

1. *D1 structures*

The Kidal assemblage shows a metamorphic foliation S1 everywhere in this area, which is attributed to the D1 event. In some places and especially in the aluminous quartzites of the Middle Proterozoic sequence, it is possible to distinguish two tectonometamorphic surfaces which have been called S1a and S1b (Boullier 1982): a metamorphic layering S1a, sometimes kyanite-bearing, is isoclinally folded and a second axial planar foliation S1b appears. The angle between S1a and S1b is always small and only a few superimposition figures have been observed; this fact suggests that D1a and D1b are generally coaxial. F1b fold axes are parallel to the L1b stretching lineation and sometimes slightly curvilinear. The superimposition of two metamorphic and tectonic events (D1a and D1b) may be seen also in basic eclogitic boudins which are stretched in the gneissic Kidal assemblage. However, S1a and S1b surfaces are not easy to observe together and a S1 penetrative, gently dipping and high grade metamorphic regional foliation is the main characteristic of the Kidal assemblage.

In between the three granulitic units (In Bezzeg, Iforas and In Ouzzal), truncations of lithological layer-

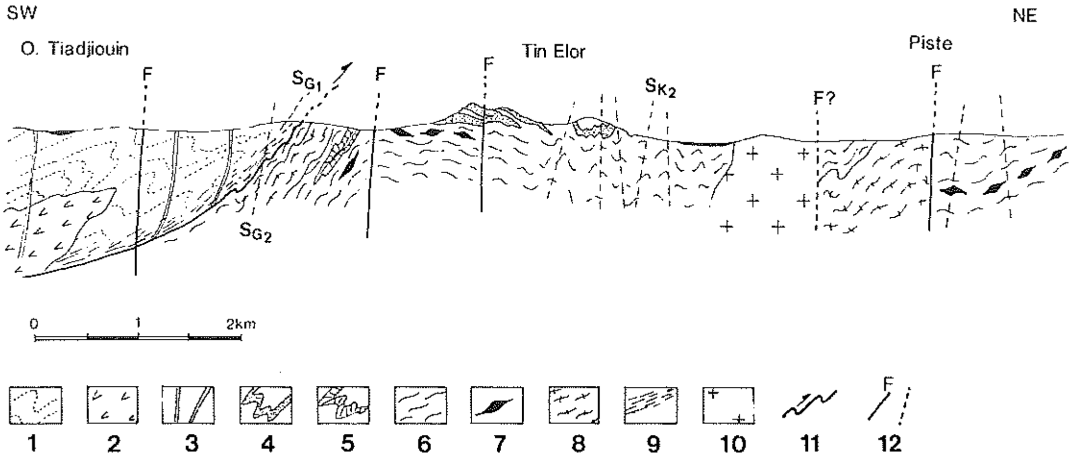

Fig. 2. Kidal assemblage section to the north of the Iforas Granulitic Unit. 1, Eburnean granulites. 2, Eburnean granitoids. 3, Pre-Pan-African doleritic dykes. 4, Middle or Upper Proterozoic quartzites. 5, Marbles (Upper Proterozoic?). 6, Middle Proterozoic alkaline gneisses. 7, Eclogitoids. 8, Pre-tectonic D1 diorite. 9, Mylonites. 10, Post-tectonic D2 granite. 11, Thrust. 12, Faults.

ing suggest the existence of internal thrust planes in the Kidal assemblage (Wright 1979, and Fig. 1), which are syn- to late-tectonic relative to D1 and which are folded by D2 in some places. These internal thrust indicate a D1 vergence toward the north. The S1 foliation (Fig. 3a) bears a stretching lineation defined by stretched or elongated minerals (feldspars, amphiboles, micas or opaques) and which has an average N–S orientation (Fig. 3b). S1 foliation and L1 lineation are interpreted as the result of intense deformation with a large component of shear (plane strain). The Iforas and In Ouzzal Granulitic Units have everywhere mylonitic contacts with the Kidal assemblage. The mylonitic foliation was developed in amphibolite facies conditions and the S1 regional foliation of the Kidal assemblage is parallel to this mylonitic foliation which may be assimilated to S1b.

On the field and except on the internal thrusts, no clear evidence for F1 structures vergence exists since stratification bedding or sedimentary structures are rarely visible, and because fold axes and stretching lineations are parallel. For this reason a study of lattice preferred orientation in quartzites was attempted (see below) to determine the sense of shear in the Kidal assemblage.

2. *D2 structures*

The F2 folds are upright to slightly overturned towards the north or northwest and are particularly well developed on the north of the Iforas Granulitic Unit, where the S1 mylonitic contact of the granulites itself is folded.

Along and within the In Ouzzal Granulitic Unit, the D2 deformation corresponds to mullions resulting from the superimposition of D1 and D2 deformation structures. On vertical axial planar S2 schistosity developed in amphibolite facies conditions, the strain markers show a N–S to N-15° horizontal elongation induced by D2; this feature suggests a constriction component. The same structures within the Tafeliant Group are interpreted as due to a shear movement by Ball and Caby (1984).

All along the margins of the Iforas and In Ouzzal Granulitic Units, the F2 folds indicate that the granulites are in the core of D2 synforms lying above the Kidal assemblage.

3. *D3 structures*

In the studied area, D3 deformation is expressed by the dextral Andjour–Tamaradant fault and by a N–S to N-20° dextral strike–slip shear-zone along the western margin of the Iforas Granulitic Unit, on which displacement has been estimated at 4 km (Boullier 1986). The structures related to that shear-zone are restricted along the western border and the northwestern corner of the Iforas Granulitic Unit where the S1 mylonitic contact is folded, sheared and partly obliterated by S3 mylonitic schistosity.

4. *D4 structures*

They are conjugate strike–slip faults (dextral N-60° and sinistral N-150°) studied by Ball (1980) and indicating a N-105° shortening direction.

MICROSTRUCTURES AND LATTICE PREFERRED ORIENTATIONS

1. *Choice of the samples*

The samples chosen for study of microstructures and lattice preferred orientation of quartz were taken in areas where D2 deformation is almost non-existent, that is where the S1 foliation is subhorizontal, essentially in between the Iforas and In Ouzzal Granulitic Units (Fig. 1). Quartzites or quartz-rich samples were chosen to avoid the effects of heterogeneous strain due to the presence of other mineral phases (Starkey and Cutforth

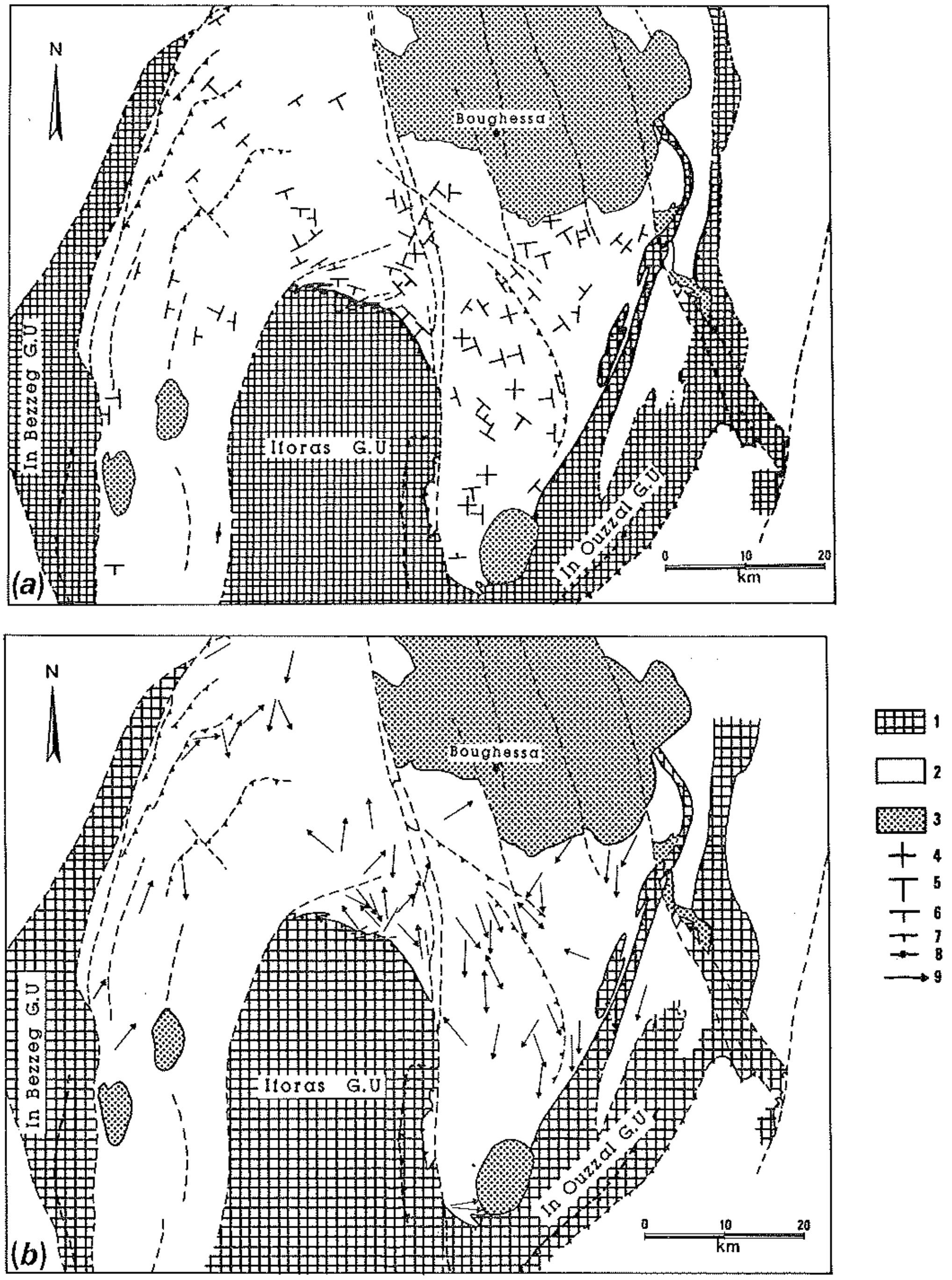

Fig. 3. Sketch map of foliation (a) and lineation (b) in the Kidal assemblage. 1, Eburnean granulites. 2, Kidal assemblage. 3, Post-tectonic intrusives. 4, Horizontal foliation. 5, Dip < 30°. 6, 30° < Dip < 60°. 7, Dip > 60°. 8, Vertical foliation. 9, Lineation.

1978). Samples showing especially high strain expressed by clearly defined foliation and stretching lineation were selected for this purpose; in such a way, there is no ambiguity on strain axes ($X > Y > Z$) which are determined on the shape of minerals such as feldspars, micas and opaque accessories.

2. *Microstructures*

All the rocks deformed by D1 only show evidence of intense annealing (coarse grained rocks, disappearance of zoning in magmatic plagioclase in metadiorites . . .) which are compatible with the high temperature conditions of the metamorphism (see below). In almost pure quartzites, exaggerated grain growth is shown by inclusions of mica, feldspar or accessories (rutile, zircon, oxide) in large undeformed quartz crystals, and indicates that grain-boundary migration (and consequently diffusion) took place after D1. That confirms that the temperature was relatively high.

The shape of quartz crystals is very significant from this point of view. When observed in a YZ thin section, the quartz grains are well elongated in the Y direction and prismatic subgrain boundaries are more or less parallel to Y. However, when observed in an XZ thin section, they are not elongated or elongated in an oblique (60° or more) direction on X; moreover, the elongation of crystals corresponds in this section to the average orientation of subgrain boundaries. Subsequently it is supposed that prismatic subgrain boundaries were transformed into grain boundaries by annealing and grain growth in a preferential prismatic direction. In this case there is no coincidence of the quartz shape fabric with the axes of the finite strain ellipsoid. This is the reason why the shape of quartz grains is not taken into account to define the strain ellipsoid (Bouchez *et al.* 1984).

3. *Lattice preferred orientation of quartz*

Six samples have been studied on the U-stage for c-axes measurements and three of those on the X-ray goniometer for ⟨a⟩ axes. The diagrams are shown in Fig. 4.

All the samples display a principal maximum of c-axes on Y and some of them a secondary maximum between the Y and XZ plane. The sample IB1206 shows a more complex pattern, that is two small circles and part of a YZ girdle.

The ⟨a⟩ axes are disposed in the XZ plane; they form a girdle with three main maxima when c-axes are mostly concentrated on Y (IB1201, CK11) or show a maximum near X when c-axes are on a girdle (CK12-5).

For the samples IB1201, CK11 and CK12-5, the pattern of c and ⟨a⟩ axes shows a monoclinic symmetry relative to the finite strain axes. However, the three other samples display an orthorhombic symmetry.

4. *Interpretation of lattice preferred orientations*

If the stretching lineation is assumed to be close to the transport direction, the c-axes pattern indicates that the slip was dominantly on the prismatic plane (maximum on Y) and probably also on the pyramidal plane (maximum between Y and XZ plane); such an interpretation of comparable diagrams has been proposed by Bouchez and Pécher (1981). There are only a few c-axes in the XZ plane, suggesting that basal slip was not active during the D1 deformation.

The X-ray goniometric investigations on ⟨a⟩ show that this crystallographic axis is disposed on the XZ plane with strongest maxima near the stretching lineation; this type of diagram indicates that ⟨a⟩ was the direction of slip. Experimental deformation of quartz provides evidence that (1010) ⟨a⟩ and (1011) ⟨a⟩ slip systems are dominant at high temperature or low strain-rate (Christie *et al.* 1964). Activation of these slip systems in the studied samples indicates that D1 deformation in the Kidal assemblage was achieved at high temperature or low strain-rate conditions which are consistent with observed microstructures and metamorphism related to D1.

The asymmetry of the c-axes diagrams relative to the finite strain frame can be interpreted in terms of rotational deformation and the sense of vorticity could be deduced from the obliquity (Bouchez *et al.* 1983). Unfortunately the senses given by the studied samples are not coherent and indicate either northwards thrusting (IB1201, CK11, IB1203) or southwards thrusting (CK12-5). From this point of view, lattice preferred orientation measurement is not a conclusive method to analyze kinematics of the D1 deformation in the Kidal assemblage. However, this study underlines the high temperature conditions of the D1 deformation.

METAMORPHIC EVOLUTION OF THE KIDAL ASSEMBLAGE

Two metamorphic stages have been shown in the Kidal assemblage: one intermediate pressure stage is indicated by kyanite in aluminous metasediments and by the existence of garnet–clinopyroxene-bearing boudins of basic rocks stretched in the S1 foliation (Sautter 1980). The second is a syntectonic high temperature stage accompanied by migmatization even in pretectonic metadiorites.

1. *Boudins of basic rocks*

They are generally fine-grained hard rocks; some of them have been recognized as pre-tectonic basic dykes intrusive in a basement or in the Middle Proterozoic quartzitic series. They contain small rounded garnets, pale green clinopyroxene with clouded core and clear rim, greenish brown hornblende, xenomorphic plagioclase, quartz, rare small flakes of biotite, rutile and ilmenite. In the outer part of the boudins large poikilitic green hornblende develops at the expense of the primary mineralogical association. Pressure shadows of the boudins are filled by plagioclasic mobilisates. Use of geothermometer (garnet–clinopyroxene; Powell 1985) and geobarometer (garnet–clinopyroxene–plagioclase; Newton and Perkins 1982, modified by Raith *et al.* 1983) on one sample (IC74) indicates a temperature range of 700° ± 50°C and pressure around 10 kb (Fig. 5).

2. *Aluminous metasediments*

In Middle Proterozoic aluminous quartzites, kyanite is observed on the north of the Iforas Granulitic Unit. It is surrounded by white micas which define the S1a foliation.

In migmatized metapelite (IB1119) the following mineralogy can be determined: leucocratic layers are made of quartz and plagioclase (An29), including sometimes kyanite grains or biotite flakes. The melanocratic layers contain biotite crystals parallel to the S1 foliation and rounded garnets with inclusions of rutile and sillima-

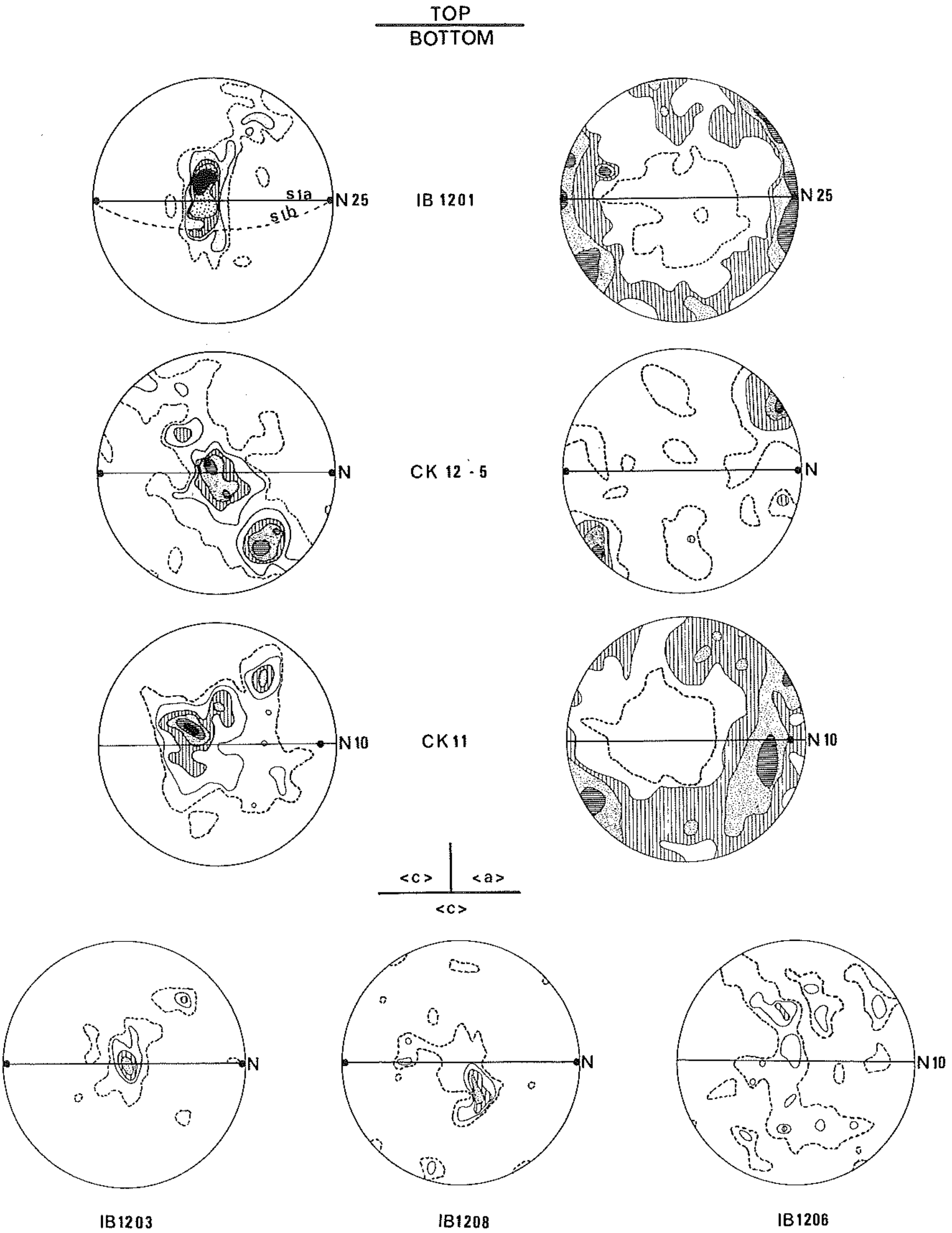

Fig. 4. Preferred orientations of quartz c and ⟨a⟩ axes for six samples located in Fig. 1. XZ diagrams. Lower hemisphere equal area projections. Solid line is the trace of the foliation plane and black point shows the lineation projection. Quartzite IB 1201 (in Boullier 1982), c-axes: 150 grains. Contours: 3, 6, 9, 12, 15, 18 measurements per 0.45% area. ⟨a⟩ axes: contours: 0.6, 1.1, 1.7, 2.25 × m.d. (mean density). Quartzite CK 12-5, c-axes: 150 grains. Contours: 3, 6, 9, 12 measurements per 1% area. ⟨a⟩ axes: contours: 1.05, 1.75, 2.55, 3.15 × m.d. Quartzite CK 11, c-axes: 140 grains. Contours: 3, 6, 9, 12, 15 measurements per 1% area. ⟨a⟩ axes: contours: 0.5, 1, 1.5, 2 × m.d. Quartzite IB 1203, 140 grains. Contours: 2, 6, 9, 15 measurements per 0.45% area. Quartzite–amphibolite IB 1208, 150 grains. Contours: 2, 4, 6, 8 measurements per 0.45% area. Quartzite–amphibolite IB 1206, 140 grains. Contours: 2, 4, 6 measurements per 1% area.

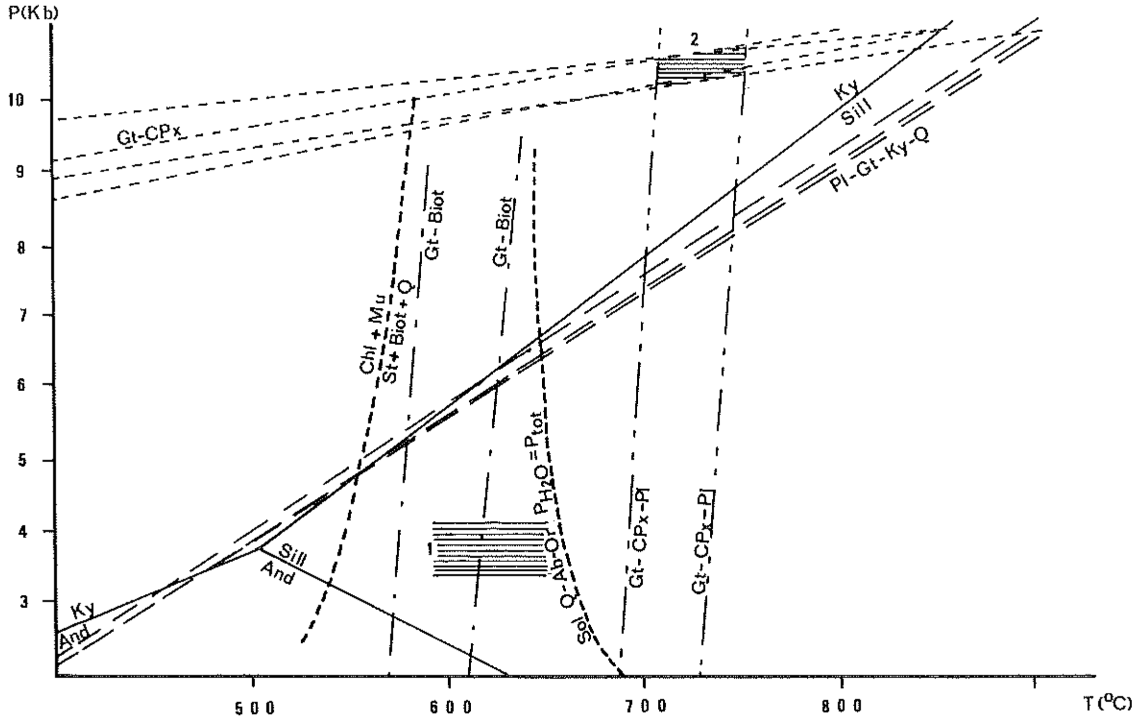

Fig. 5. Diagram indicating the *P.T.* conditions determined from metapelite and boudins of basic rocks of the Kidal assemblage. 1, Iforas granulites domain. 2, Boudins of basic rocks domain.

nite needles, deformed staurolite and kyanite tablets including small biotites and blebs of quartz. Staurolite and kyanite lie in large muscovite flakes in which tiny needles of sillimanite are included. Graphite, rutile, ilmenite and zircons are accessory minerals. Chlorite is occasionally developed from biotite.

In IB 1119, kyanite may be related to a first intermediate pressure stage. Subsequently migmatization took place in the kyanite stability field as suggested by kyanite inclusions in plagioclase; occurrence of graphite indicates that P_{H_2O} was probably lower than P_{tot}, consequently the pressure was greater than 7 kb. On the contrary, crossing of the solidus during retrogression took place in the sillimanite field as shown by the association of muscovite and sillimanite. A tentative estimate of *P–T* conditions has been made from mineralogical associations: garnet–plagioclase–kyanite–quartz using Newton and Haselton's geobarometer (1981) based on Ganguly and Saxena's model (1984) of solid solution, and garnet–biotite geothermometer (Ferry and Spear 1978). The results obtained by these methods are not consistent with petrographical observations and it is suggested that the calculated temperature (lower than the granitic solidus) does not represent a position on the prograde *P–T* path but a stage of retrogression. Likewise, pressure is underestimated.

At the same time, deep levels of the Iforas Granulitic Unit underwent a prograde metamorphism which is shown by prograde anhydrous reactions in some metapelites and pyrigarnites; estimation of *P–T* conditions indicates a low pressure ($P = 3.5$ kb) and high temperature (600–650°C) metamorphism (Barbey and Boullier, in preparation). However, the Iforas Granulitic Unit as well as the In Bezzeg Granulitic Unit show more or less intense but ubiquitous hydration as witnessed by the development of green hornblende in subalkaline gneisses and pretectonic doleritic dykes. The grade of metamorphism is generally amphibolite facies except in the vicinity of the unconformable sedimentary cover (high level of the Granulitic Unit) which suffered a greenschist facies metamorphism (Boullier 1982). The hydration of the granulitic units during the D1 event is attributed to the dehydration of the Middle and Upper Proterozoic metasediments in the Kidal assemblage underlying the granulitic nappes.

DISCUSSION

The D1 deformation in the Kidal assemblage is interpreted in terms of thrust tectonics involving the Iforas Granulitic Unit (Boullier *et al.* 1978). The movement direction is approximately N–S as shown by the stretching lineation. Geochronology of the Pan-African events within the Kidal assemblage is not precisely known. Ball and Caby (1984) consider that the N–S vertical foliation of the volcanosedimentary Tafeliant Group (SW of the studied area) is equivalent and contemporaneous to the thrust tectonics described in the Kidal assemblage; following this interpretation, D1 thrust tectonics should be younger than 696 + 8/−3 Ma, the age of an intrusive rock in the basement of the Tafeliant Group, and more or less around 613 ± 3 Ma (U/Pb on zircon, Ducrot *et al.* 1979) or 595 ± 24 Ma (Rb/Sr whole rock isochron, Liégeois and Black 1984), the age of a syn- to late-tectonic granodiorite intrusive in the Tafeliant Group.

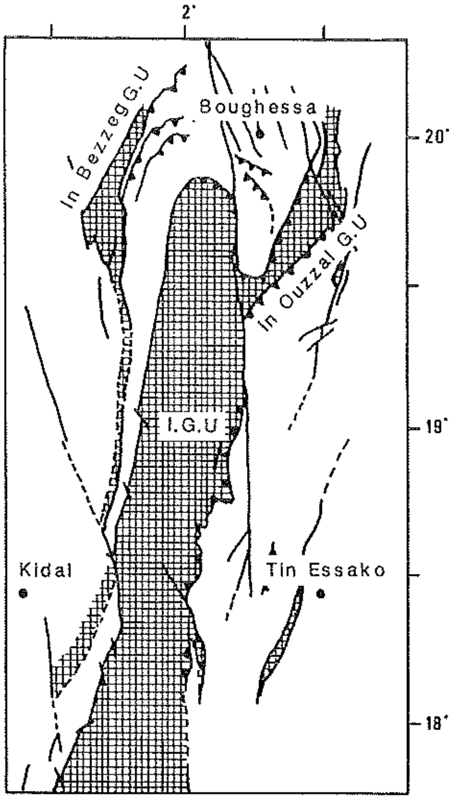

Fig. 6. Repartition of granulitic outcrops in the Adrar des Iforas.

Actually the deformation of the Tafeliant Group is very similar to D2 deformation of the Kidal assemblage and In Ouzzal Granulitic Unit, deformation to which geochronological data attribute a similar age (*ca* 600 Ma, Bertrand *et al.* 1984). That is to say that at the present time we do not have clear data on the D1 deformation in the Kidal assemblage.

Looking on the map of granulitic outcrops, three of them could be a root zone of the Iforas Granulitic Unit nappe: the In Bezzeg Unit, the In Ouzzal Unit and the Tin Essako Unit (Fig. 6). Furthermore, other granulitic units overlying gneisses resembling the Kidal assemblage have been pointed out by Russian geologists in Algeria (Kiniakine pers. comm.). From this point of view it was important to know the sense of movement. In this respect our study of the lattice preferred orientation is inconclusive as it does not allow confirmation of any sense of movement. This is partly due to the high temperature of the deformation and to the activation of the prismatic ⟨a⟩ slip system which generally produces orthorhombic diagrams.

However, northern vergence of D1 structures in Tin Essako area (Davison 1980), within marbles in the Kidal area (Wright 1979) and in the Kidal assemblage between the In Bezzeg and Iforas Granulitic Units (internal thrusts, D1b vergence in migmatites) indicates that thrusting probably took place northwards. These structural observations suggest that the Tin Essako Granulitic Unit is the root zone of the granulitic nappe (movement towards the NNW, Boullier *et al.* 1978, Wright 1979, Davison 1980).

The metamorphic evolution of the Kidal assemblage (intermediate pressure followed by low pressure–high temperature) is typical of a crust thickened by thrusting (Oxburgh and Turcotte 1974, Rybach *et al.* 1977, England and Thompson 1984). From the geothermobarometric data on the boudins of basic rocks and metapelites, thickness of the nappe(s) above the Kidal assemblage may be estimated as 20 km at least (7 kb) and probably more (10 kb registered in basic rocks). As the unconformable sedimentary cover lying on the Iforas Granulitic Unit underwent a greenschist facies metamorphism, it is assumed that the granulitic nappe was overlain by almost 10 km of allochthonous terranes which are represented by metasediments in the Ibedouyen area and in a synform on the northeast of the Iforas Granulitic Unit (Boullier *et al.* 1978, Boullier 1982).

The relatively high temperatures observed below the nappe when compared with the values calculated by England and Thompson (1984) suggest a high geothermal gradient prior to the nappe emplacement. That is consistent with what is known about the pre-tectonic magmatism: the tholeiitic lavas interlayered in the sediments within the Kidal assemblage indicate that the continental crust had suffered extension before the thickening event (Leterrier and Bertrand 1986). This stretching and heating of the crust also lowered its strength. It is probably the reason why high-strain was concentrated in this thin crust.

Intermediate pressure parageneses are only known between the In Bezzeg Granulitic Unit and the Iforas Granulitic Unit. If they represent the loci of deepest terranes under the nappe, then the In Bezzeg Granulitic Unit and its prolongation should be the root zone of the granulitic nappe (movement towards the NNE). Consequently geometric interpretation of the nappe pile and its root zone differs depending on structural or metamorphic considerations. This uncertainty is due to intense deformation during the collision (D2 and later events) which modified the geometry of the Central Iforas.

Caby (1970) describes the same succession of events in North–Western Hoggar:

A first deformation contemporaneous with a barrowian type metamorphism develops a subhorizontal foliation and isoclinal folds with southwards vergence. The thrust tectonics described by Caby *et al.* (1985) in the Middle Proterozoic quartzites of the Ahnet Mountains (north of the In Ouzzal Granulitic Unit) may be related to the same event but display a northwards sense of movement.

A second deformation (upright folds) corresponds to an east–west shortening and is followed by strike–slip faults or shear zones.

Then a tangential barrowian type tectonometamorphic event with N–S transport direction is known along the entire Trans-Saharan Pan-African belt of Mali and Algeria. This event cannot be related in a simple way to the collision between the West African Craton and the mobile belt even if it is supposed that D1 and D2 are two events of the same progressive deformation. It has been interpreted as the result of a first collision with a northern continent represented by the Tassendjanet basement (Caby *et al.* 1981). However, if the interpretation of the latest events (D2, D3 and D4) related to the collision with the West African Craton is based on many geochemical and geochronological data, these are very scarce on the D1 event which has been moreover obliterated by the subsequent deformation. Any geodynamic reconstitution of D1 would be speculative considering the present stage of our knowledge.

Acknowledgements—This research has been supported by the A.S.P. Afrique (C.N.R.S.). We acknowledge the support and interest of S. Diallo, Director of D.N.G.M. (Bamako, Mali). We thank R. Caby, J. M. Bertrand, J. Leterrier and F. Lapique for providing samples and fruitful discussions. We are grateful also to F. Lhote and J. P. Uriot for the ⟨a⟩ axes measurements on the X-ray goniometer.

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