MINERALOGICAL STUDIES OF GONDWANA SEDIMENTS FROM KORBA COALFIELD, MADHYA PRADESH, INDIA. PART V—MINERALOGY OF SILT FRACTION, COARSE FRACTION STUDY, AND PETROGRAPHY

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ABSTRACT

Silt fraction, coarse fraction (pebble, coarse and medium sand) and thin sections of the borehole samples of Korba Coalfield are studied. X-ray study of silt fraction showed that (i) Talchir sediments are characterized by low kaolinite content, and presence of both plagioclase and alkali felspars, denoting cold climate. (ii) Transition zone (zone IB) just above the Talchirs also contains both plagioclases and alkali felspars, though sand fraction of this zone lacks plagioclases (iii) Barakar sediments are marked by abundance of kaolinite, suggesting warm, humid climate (iv) Kaolinite content of sandy beds is higher than that of shale beds. Coarse fraction of Talchir sediments are marked by aboundance of metamorphic rock fragments and angular quartz grains. Barakar sediments lack rock fragments, but quartz grains are subangular, suggesting a short transport history. Petrographically, Barakar sandstones are arkose wacke. Kaolinitization is the most important diagenetic process which has affected felspars and ferromognesion minerals. Complete kaolinitization of felspar grains has produced secondary matrix.

INTRODUCTION

Deposition in a sedimentary basin is controlled by various factors, e.g. geomorphology, climate, vegetation, provenance, depositing medium, etc. Partial information on sedimentation history of a deposit can be obtained by the specialized studies like palynology, clay mineralogy, sieve analysis, etc. Mostly, sedimentary sequences are studied only from one or the other point of view; for instance, if palynological studies are done, mineralogy is not considered. If sand fraction is studied clay fraction study is neglected.

Core samples of a borehole profile (Bore hole no. NCKB-19) of Lower Gondwana from Korba Coalfield, Madhya Pradesh have been studied in detail from several point of views, and some results are already published: palynological studies (BHARADWAJ & SRIVASTAVA, 1973), general mineralogy (SINGH & SHARMA, 1973) quartz grain surface features (SINGH, 1974a), clay mineralogy (SINGH, 1974b), heavy minerals (SINGH, 1975).

This paper embodies the results of the study of silt fraction, petrography and coarse fraction study of the above bore hole.

MINERALOGY OF SILT FRACTION

General

Silt fraction (63-2 μ) is normally neglected in the mineralogical study of sediments. Mostly, either the study of sand fraction or clay fraction is emphasized, and no investigations of the silt fraction are undertaken. In order to get more complete data on the mineraological characteristics the silt fraction of a bore hole profile from Korba Coalfield has also been studied.

METHODS

Silt fraction was separated from sand by wet sieving through a 63 μ sieve, and from clay fraction by sedimentation in Atterberg cylinders (SINGH, 1974b). Mineral determination in silt fraction was undertaken by X-ray diffraction analysis. For this purpose silt fraction was gently ground and a thick slurry was prepared. Few drops of this slurry were placed on a glass slide and dried to obtain a sample slide with preferred orientation of flaky minerals. This slide was exposed to X-ray using a Phillips (Müller Mikro II) difffractiometer (SINGH, 1974b). Diffractograms were prepared at room temperature.

For the identification of minerals, peaks on the diffractograms were indexed, their spacing values were calculated, and the various minerals were identified. Following minerals were identified: chlorite, illite, kaolinite, quartz, alkali felspar, plagioclase felspar, mixed layer mineral, and montmorillonite.

Height of a peak, on a trace of X-ray diffractogram can be taken as a rough measure of its amount in the sample. Height of the 14 Å peak was taken as a measure of chlorite; similarly, 3.24Å peak for alkali felspar, and 3.19Å peak for plagioclase felspar. 7 Å peak is characteristic of kaolinite, however 002 peak of chlorite interferes with this peak. But in silt fraction of Gondwana samples content of chlorite in relation to kaolinite was very low. So height of 7 Å peak was taken as rough estimate of kaolinite content. The quartz peak at 3.34 Å has 100 intensity, but it interferes with mica peak of 003 spacing at 3.33 Å. A quartz peak at 4.26 Å has 35 intensity; peak height of 4.26 Å × 3 was taken as a measure of quartz content. Moreover quartz/felspar, and kaolinite/illite ratios were calculated.

MINERALOGICAL COMPOSITION

Data of the mineralogical composition of the silt fraction of various samples has been tabulated in Table 1. Diffractograms of some of the silt fractions are shown in Text-figure 1. In the following mineralogical characteristics of silt fractions of various palynological zones shall be discussed.

Zone IA

Silt fractions of the samples of this zone are characterized by the presence of both alkali- and plagioclase felspars, low quartz/felspar ratio, and low kaolinite/illite ratio. Montmorillonite and mixed layer mineral are present. Sample no. 136 contains some calcite.

Zone IB

Quartz/felspar ratio is low, both plagioclase- and alkali felspars are present. Kaolinite illite ratio is higher than in zone IA but much lower than in the rest of the succession Montmorillonite and mixed layer mineral are present.

Zone IIA

Only alkali felspars are present. Quartz/felspar ratio increases in relation to zone IA and IB and is rather high. Mixed layer minerals are present.

Zone IIB

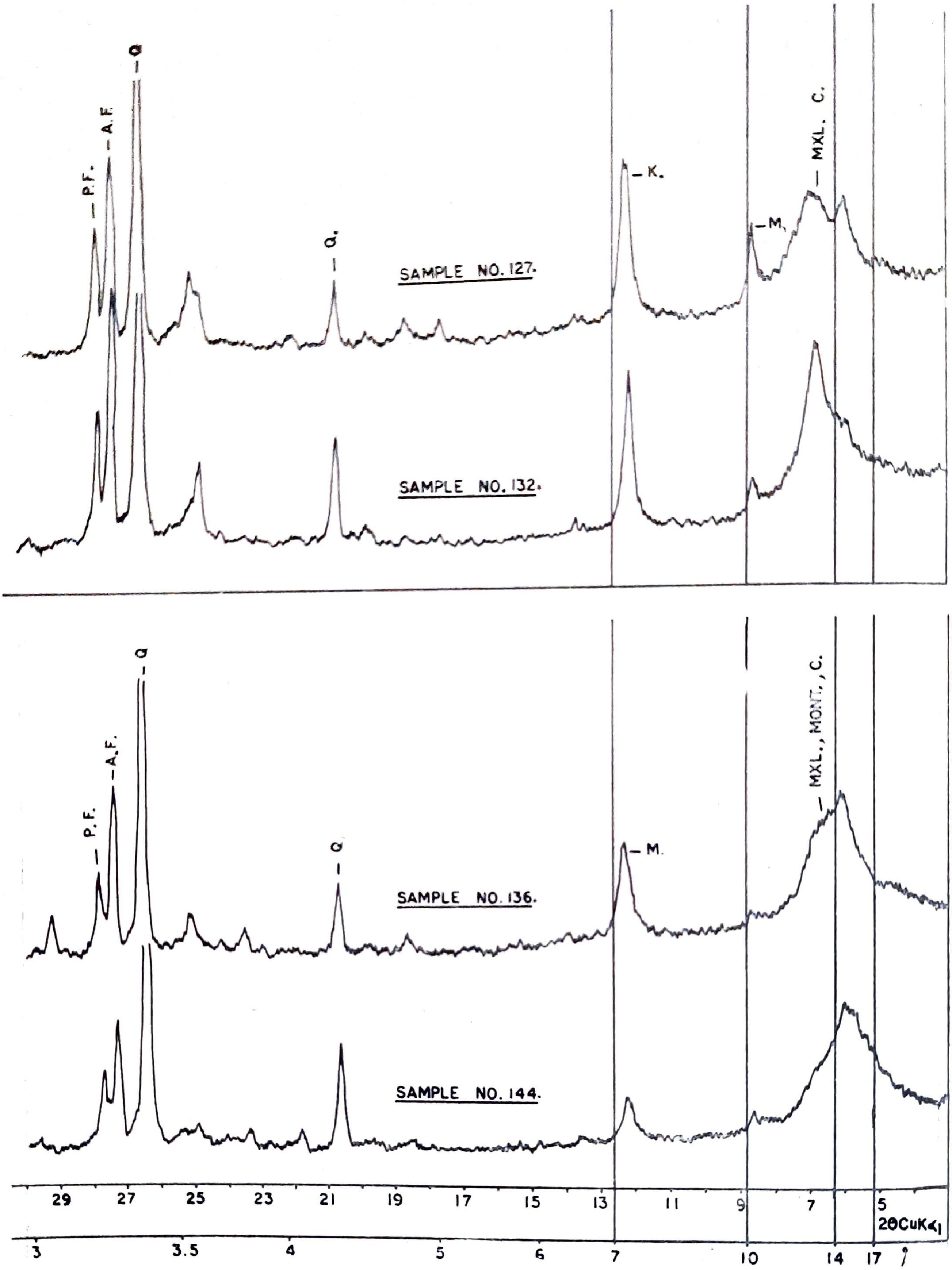
Only alkali felspars are present, kaolinite/illite ratio is high. Quartz/felspar ratio is somewhat lower than in zone IIA. Mixed layer minerals are present.

Table 1—Semi-quantitative estimate of the main minerals in silt fraction. Height of the respective peaks in mm is taken as a measure of the content of that mineral.

Sample No.	Chlorite (14Å peak)	Mica (10Å peak)	Kaolinite (7Å peak)	Quartz (4.26Å peak)	Alk. felspar (3.24Å peak)	Plag. felspar (3.19Å peak)	Remarks	Quartz/ felspar ratio	Kaolinite/ illite ratio	Lithology	Palyno-logical zone
1	..	22	>224	40	98	..		1.2	>10.2	coarse-grained sst	
4	..	18	>225	28	61	..		1.4	>12.5	coarse-grained sst	
6	..	42	>229	31	107	..		0.9	>5.5	coarse-grained sst.	
9	..	60	>230	90	108	..		2.5	>3.8	medium-grained sst	
10	..	87	>230	59	62	..		2.9	>2.6	medium-grained sst	
12	10	146	202	118	215	..		1.6	1.4	sandy shale	
14	traces	32	>216	44	>220	..		<0.6	>6.8	coarse-grained sst	IIIB.
15	10	45	164	84	162	..		1.6	3.6	shaly coal	
20	traces	39	>213	42	50	..		2.5	>5.5	medium-grained sst	
21	..	39	182	78	150	..		1.6	4.7	shaly coal	
28	15	79	>227	25	64	..		1.2	>2.9	shaly coal	
35	..	21	70	16	22	..		2.2	3.3	medium-grained Sst	
40	traces	90	152	35	96	..		1.1	1.7	medium-grained Sst	
42	15	115	135	31	67	..		1.4	1.2	sandy shale	
48	14	48	199	28	182	..		0.5	4.1	coarse-grained sst	
52	..	..	97	18	..	..		..	..	sandy shale	
55	traces	23	>221	24	34	..		2.1	>9.6	shaly sst	
56	traces	81	>222	40	90	..		1.3	>2.7	sandy shale	
57	..	54	>211	30	70	..		1.3	>3.9	medium-grained sst	IIIA
61	14	47	>214	50	59	..		2.5	>4.6	sandy shale	
66	traces	10	>223	35	>227	..		<0.4	>22.3	coarse-grained sst	

Table 1 (Contd.)

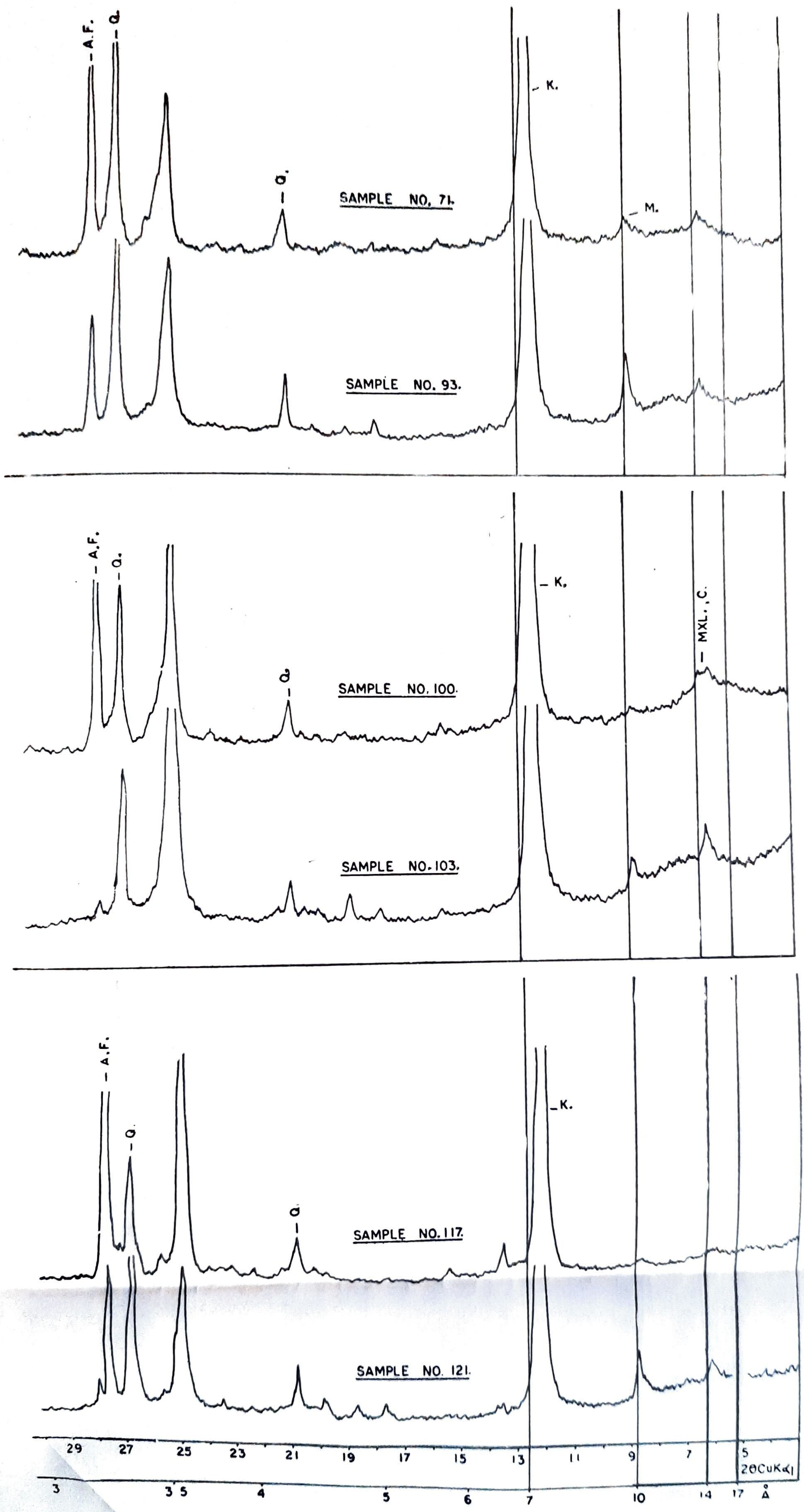
68	..	34	208	95	33	..		8.6	6.1	shale	
71	17	18	>194	31	143	..		2.2	>10.8	medium grained sst	IIIA
77	..	25	>223	38	>225	..		<0.5	>8.9	medium grained sst	
83	traces	23	>218	20	140	..		0.4	≥9.5	coarse grained sst	
91	..	15	80	17	..	..			5.3	shaly sst	
93	18	45	210	41	77	..	mixed layer mineral in minor amounts.		5.3	shaly sst	
95	15	27	>228	41	135	..		1.9	>8.4	medium grained sst	IIB
100	25	traces	>205	28	139	..	mixed layer mineral present ..	0.6	..	medium-grained sst	
103	28	23	>215	26	14	..	minor amounts of mixed layer min.	5.6	>9.4	shale	
107	..	51	>229	49	85	..	minor amounts of mixed layer min.	1.7	>4.5	grey shale	
111	13	35	>212	29	26	..	minor amounts of mixed layer min.	3.3	>6.1	medium-grained sst	IIA
114	45	54	>215	45	traces	..		..	>4.0	shale	
117	traces	traces	>223	30	>230	..		<0.4	..	very coarse-grained sst	
121	17	32	174	36	106	24		0.8	5.4	shale	
127	52	45	91	39	113	72	mixed layer & montm.	0.6	2.0	medium-grained sst.	IB
130	traces	21	49	86	>229	138	mixed layer & montm.	<0.7	2.3	shale	
132	traces	20	90	60	148	76	mixed layer montm.	1.8	4.5	shaly sst.	
134	traces	33	51	55	70	20	montm. & mixed layer min.	1.8	1.4	shaly sst	
136	traces	10	56	43	101	51	montm. & calcite are present	0.8	5.6	shaly sst	IA
142	traces	23	22	42	92	66	montm. is present	0.8	0.9	pebbly sst	
144	..	12	27	62	77	48	montm. is present	1.5	2.3	pebbly sst	

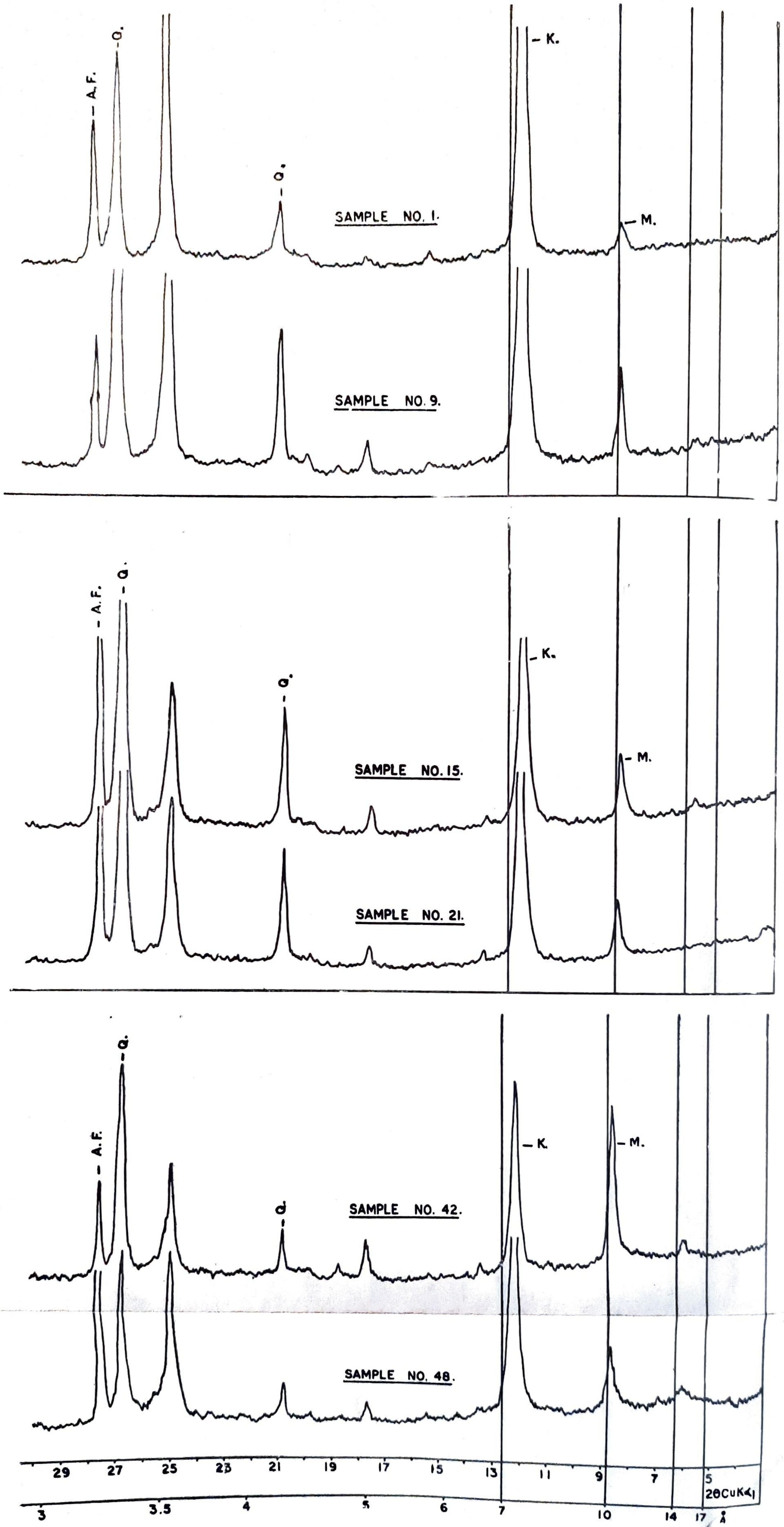


Text-figure 1 (*a—c*)—Diffractograms of few selected silt fractions. Various mineral peaks are marked. P. F.—Plagioclase felspar, A. K.—Alkali felspar, Q—Quartz, K—Kaolinite, M—Mica, C—Chlorite, Mont.—Montmorillonite, MXL—Mixed layer mineral.

Zone IIIA

Only alkali felspars are present. Kaolinite/illite and quartz/felspar ratios are high. Only in few samples mixed layer minerals are present.


A.F.
Q.
K.
SAMPLE NO. 71.
M.
SAMPLE NO. 93.
SAMPLE NO. 100.
MXL., C.
SAMPLE NO. 103.
SAMPLE NO. 117.
SAMPLE NO. 121.
29 27 25 23 21 19 17 15 13 11 9 7 5
2θCuKα1
3 3.5 4 5 6 7 10 14 17 Å



A.F.
Q.
K.
M.
SAMPLE NO. 1.
SAMPLE NO. 9.
SAMPLE NO. 15.
SAMPLE NO. 21.
SAMPLE NO. 42.
SAMPLE NO. 48.
29 27 25 23 21 19 17 15 13 11 9 7 5
2θCuKα1
3 3.5 4 5 6 7 10 14 17 Å

Zone IIIB

Only alkali felspars are present. Kaolinite/illite ratio increases towards top of the sequence.

DISCUSSION

If we look at the distribution of various minerals in silt fraction of the borehole profile (see Table 1), we will observe that except for zone IA and IB, all the samples are marked by the dominance of kaolinite. Kaolinite in the samples is well-crystallized and present as large crystals. Mica is present in almost all the samples, and its content is higher in the clay fraction of the same sample (SINGH, 1974b). Plagioclase felspars are present only in zone IA and IB; all other samples contain only alkali felspars in varying amounts. Quartz is, of course, an ubiquitous mineral present in all the samples in varying amounts.

Abundance of kaolinite also in silt fraction of Barakar sediments proves further that weathering in the provenance was undergoing mainly under humid and warm climate, with well-drained environment. Only lower part of the succession (Talchirs) with low kaolinite content are deposits of cold climate. Zone IA, deposits of glacial environment contains both plagioclase- and alkali felspars. Moreover, sediments of zone IB, which are certainly fluvial deposits also contain abundant plagioclases along with alkali felspar. It suggests that during deposition of zone IB climate was rather cold temperate.

In sand fraction, plagioclase felspars are present only in zone IA, and are totally absent upward in the sequence (SINGH & SHARMA, 1973).

It is suggested that during deposition of zone IB climate was rather cold, and material for deposition might have been derived from glacial sediments. During the process of deposition by rivers plagioclases in the sand fraction must have been destroyed, but smaller grains of plagioclases in silt fraction escaped destruction.

Presence of plagioclase felspars in zone IB points to the fact that plagioclase felspars in the silt size can be retained for longer period than in the sand fraction under non-glacial conditions. Thus, felspar content of sand fraction is more susceptible to climate than that of silt fraction. Another interesting feature is that shale horizons possess a lower kaolinite/illite ratio than the adjoining sandy horizons This phenomenon can be explained as a result of kaolinitization during diagenesis preferentially in sandy horizons causing an increase in kaolinite content.

COARSE FRACTION STUDY

General

Several samples of the investigated borehole profile contain fraction >2.0 mm. In order to obtain an idea about the composition and shape characteristics of the coarser fractions, sieve fractions were studied with the help of a binocular microscope. For this purpose following sieve fractions were observed: >1.0 mm, 1.0-0.6 mm and 0.6—0.3 mm. General roundness of the quartz grains was determined by comparison with visual charts given by POWERS (1953).

SYSTEMATIC DESCRIPTION

The characteristics of the coarse fraction in some of the selected samples are given below:

Sample no. 142 (Plate 1, Figs. 1-3)

This sample represents glacial deposit. The fraction >1.0 mm is composed exclusively of metamorphic rock fragments, mostly garnetiferous mica schist. Few quartzite fragments are also present. All the fragments are very angular suggesting poor reworking of the grains. 1.0-0.6 mm fraction is very similar to >1 mm fraction, and is made up of very angular grains of metamorphic rock fragments. 0.6-0.3 mm fraction contains almost 30-40% quartz grains; rest are rock fragments. Quartz grains are variable in shape, mostly with low sphericity; they are angular to subangular in outline.

Sample no. 136

This sample also belongs to glacial deposits. >1.0 mm fraction is made up of angular rock fragments of garnetiferous mica schist, few fragments of quartzites or quartz veins are also present. 1.0-0 6 mm fraction is similar to >1 mm fraction. 0.6-0.3 mm fraction is made up of 40% quartz, and the rest is rock fragments. Quartz grains are equidimensional but are angular in outline.

Sample no. 117 (Plate 2, Figs. 4-6)

This sample is from fluvial deposits and represents coarse-grained channel sand facies. >1.0 mm fraction is composed of only subangular quartz grains. 1.0-0.6 mm fraction contains angular quartz 'grains; small amounts of cleavage fragments of felspars are also present 0.6-0.2 mm fraction shows angular, equidimensional quartz grains. Some quartz grains are exceptionally angular, almost splintary in appearance.

Sample no. 107

The sample belongs to sand-shale intercalation facies of fluvial environment. 1.0-0.6 mm fraction is made up of subangular to subrounded quartz grains.

Sample no. 100 (Plate 2, Figs. 7-9)

This sample represents channel sand facies. >1.0 mm fraction is made up of equidimensional, predominantly subrounded quartz grains. 1.0-0.6 mm fraction shows quartz grains, which are subangular in outline. 0.6-0.3 mm fraction is made up of subangular to angular quartz grains.

Sample no. 83

This sample represents channel sand facies. >1.0 mm fraction is made up of subangular quartz grains. 1.0-0.6 mm fraction consists of angular to subangular quartz grains. Few grains of felspars are also present.

Sample no. 77 (Plate 3, Figs. 10, 11)

This sample belongs to channel sand facies. >1.0 mm fraction is made up of subangular to angular quartz grains, few quartz grains are very angular. Quartz grains of 0.6-0.3 mm fraction are predominantly subangular to angular in ourline.

Sample no. 55 (Plate 3, Fig. 12; Pl. 5, Fig. 13)

This sample belongs to shale-sand intercalation facies. >1.0 mm fraction is made up of very angular to angular quartz grains. Some of the quartz grains are dark coloured. 1.0-0.6 mm fraction contains predominantly angular to subangular quartz grains. Some quartz grains are elongated and very angular. Few grains are also subrounded.

Sample no. 14 (Plate 3, Figs. 14, 15)

This sample belongs to channel sand facies. >1.0 mm fraction is made up of angular to subangular quartz grains. 1.0-0.6 mm fraction is made up of subangular to subrounded quartz grains. Some of them are very angular.

Sample no. 1

This sample represents channel sand facies. >1.0 mm fraction is made up of angular quartz grains. Some composite grains are also visible, which are left integrated during preparation of samples. 1.0-0.6 mm fraction is made up angular to very angular quartz grains. Few felspar grains are also seen.

DISCUSSION

Out of all the samples studied only two belong to glacial deposits, i.e. Sample nos. 142 and 136. These samples are characterized by the abundance of metamorphic rock fragments in coarser fractions. >1.0 mm fraction is made up almost exclusively of rock fragments. Quartz grains are present in fraction >0.6 mm, and they are very angular to subangular in shape.

Other samples, i.e. sample nos. 117, 107, 100, 83, 77, 55, 14 and 1 are from fluvial deposits. Samples have been studied both from channel sand and sand-shale intercalation facies. Rock fragments are absent; quartz grains are angular to subrounded. All the samples show a decrease in roundness characteristics from coarser to finer fractions. In other words, coarser fraction of a sample possesses better rounded grains than the finer fraction of the same sample. However, wear and tear effect on the quartz grains is low even >1.0 mm fraction is dominated by subangular quartz grain

This suggests that these sediments had a relatively short transport history. The sediments from the provenance were quickly eroded and transported by rapidly flowing small rivers in humid climatic conditions. Sediments were quickly deposited in a rapidly sinking basin, giving little opportunity for the mechanical wear and tear of the sediment grains.

PETROGRAPHY

General

To obtain an insight into the interrelationship of various mineral components, and the diagenetic features, thin-sections of nine samples, namely sample nos. 9, 11, 48, 50, 57, 64, 77, 83 and 85 have been studied. (Unfortunately, during the floods of Gomti River in the year 1972, all other samples stored in the basement of BSIP were destroyed). The samples studied belong to Barakar, and are very similar in nature. A combined description of petrography is given below.

Thin section description

All the samples are fine- to medium-grained sandstones. Mineralogically, they are felspathic sandstone, and can be specifically termed as arkoses. Model analysis of the two samples is given in Table 2. In the model analysis a distinction between primary and secondary matrix has been made. Secondary matrix has been produced due to alteration of felspar (also some mica) into kaolinite (see page 57). Thus, secondary matrix +felspar denote the original content of felspar, i.e. the composition of the rock is ca. 60% quartz, 25% felspar, 12% matrix, and 3% mica. This is typical composition of an arkose.

Table 2—Model analysis of the two sandstone samples

	Sample no. 11	Sample no. 64
Quartz ..	60	60
Felspar ..	13	10
Mica ..	1	2
Primary matrix ..	12	16
*Secondary matrix ..	14	12

*Secondary matrix means matrix produced due to alteration of felspar and mica grains.

Fabric of the sandstone is typically of a lithic arenite. The rock is supported by a quartz-felspar framework. Grain contacts are few. Matrix is low in content, but is an important constituent, and surrounds most of the grains from all the sides and binds the framework together (Plate 4, Figs. 16, 17). Even when grains are in direct contact with each other no pressure solution features are developed. Some squeezing of matrix and mica flakes around the framework grains has taken place (Plate 5, Fig. 20). Cement is rare; and is represented by iron oxide. Generally speaking, sediment is poorly sorted and is immature—both texturally and mineralogically. Matrix is mostly dirty coloured and is made up of mainly kaolinite with minor amount of quartz. Content of matrix varies from sample to sample. Under high magnification matrix is seen to be made up of kaolinite aggregate of varied crystallinity and granularity and small quartz grains. Some parts are extremely fine-grained looking almost isotropic. Mostly randomly oriented fans, worms of kaolinite are present (Plate 6, Figs. 25, 26). As detrital framework grains metamorphic rock fragments, mica flakes, chlorite are also present in negligible amounts.

Detrital grains

Quartz—is the most abundant constituent. Grains are subangular, corners and edges are rather sharp suggesting only little wear and tear during transport. Grains are mostly monocrystalline; few polycrystalline grains are also present.

Felspar—is the other important constituent. Felspar grains show better rounding than the quartz grains. It is because of less resistance to wear and tear of felspar. Microcline is most abundant; occasionally they are strikingly fresh. Among other felspars, grains of orthoclase and sodic plagioclases are seen in different stages of alteration.

Rock fragments—are rare. All the rock fragments observed are of quartz-felspar rocks of metamorphic origin.

Mica—is low in content. Both Muscovite and biotite are present. Muscovite occurs mainly in elongated flakes, while biotite is present mainly as broad flakes. Mica has been moderately to strongly altered during diagenesis.

Chlorite—Few grains of green coloured chlorite are invariably present.

Accessory minerals—Few grains of garnet, zircon, epidote, hematite, limonite, ilmenite, leucoxene have been recorded.

Matrix—Matrix of a sediment represents original fine-grained material in which larger grains are embedded. Matrix of the sandstones studied has been specially investigated.

Matrix is dirt coloured to light brown or greenish. Greenish colour is because of chlorite content, whereas brown colour is due to iron oxide content.

Matrix is essentially kaolinitic made up of minute worm-like kaolinite crystals of variable size. When crystal size is too small matrix seems to be isotropic in which larger kaolinite crystals are visible. Occasionally, minute grains of mica, quartz, and felspar are also included in the matrix. Presence of kaolinite as main mineral in the matrix has been confirmed by the study of clay minerals in $>2\ \mu$ fraction (SINGH, 1974b). Genetically two types of matrix as distinguishable.

(1) Primary matrix—It is fine-grained material coming from source rock and included in the sediment at the time of deposition. It is seen as a thin rim around the framework grains (Plate 4, Fig. 18).

(2) Secondary matrix—During post depositional history ferromagnesian minerals and felspars have been kaolinitized. In the process larger detrital felspar or mica grains have been altered into an aggregate of kaolinite. The boundary between such altered grains and primary matrix is ultimately obliterated. This is seen in thin section as large areas of matrix, comparable in size to framework grains (Plate 4, Fig. 19).

The problem of secondary matrix in sandstones has been discussed by several workers. Recently, PETTIJOHN, POTTER AND SIEVER (1972) provide a discussion on the problem of secondary matrix in graywackes. CUMMINS (1962) noted for the graywackes that not all the matrix is primary detrital. Much matrix is a diagenetic product produced by the alteration or unstable framework grains and fills the interstices. DICKINSON (1970) discusses various kinds of matrix and gives criteria for their identification. In the rocks studied here development of secondary matrix has produced gaps in the framework with relict fragment texture. The boundary between grain and primary matrix is obliterated. Amount of secondary matrix is almost equal to the primary matrix. Text-figure 2 shows schematically the development of secondary matrix in the rocks of Korba Coalfield.

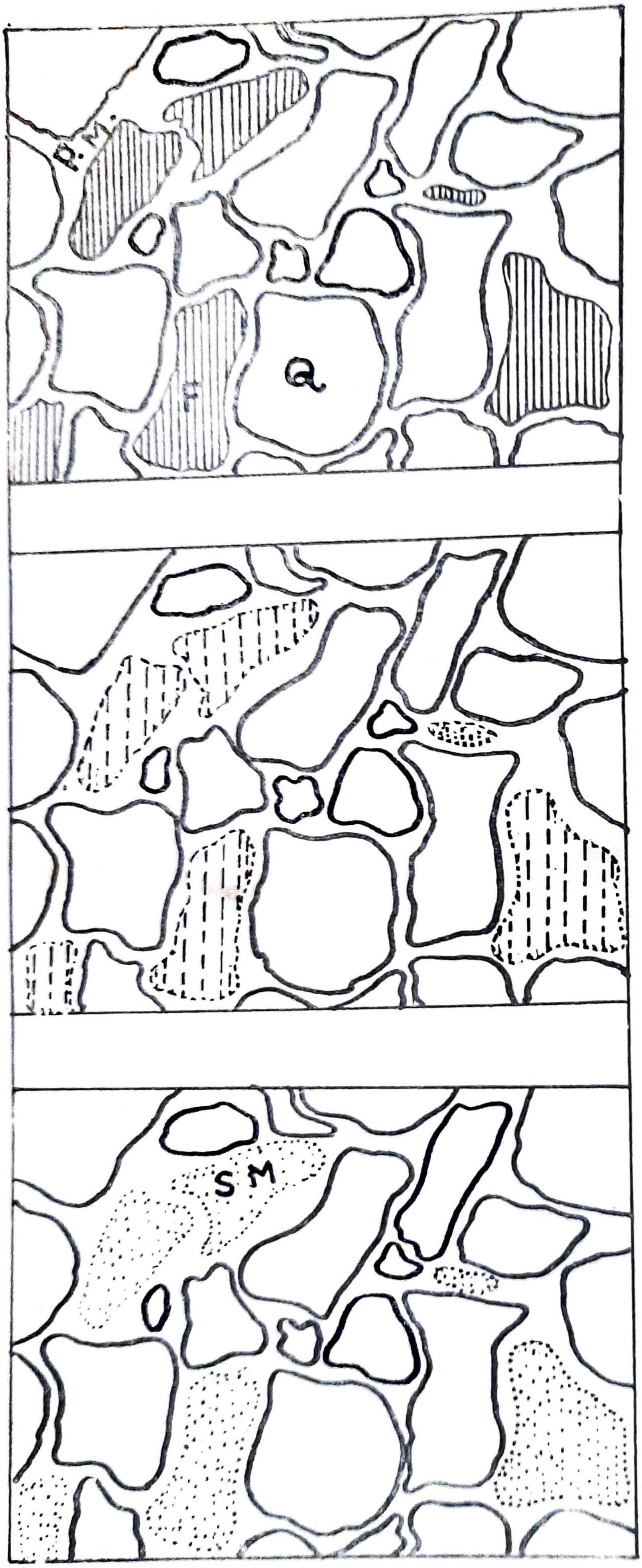
DIAGENESIS

The term diagenesis denotes all the processes, both physical and chemical, which affect sediment after deposition, excluding the process of metamorphism. In the Gondwana sandstones effects of following diagenetic processes are observed.

(1) *Compaction*—In the sandstone some pronounced effect of compaction are evident. Sandstones possess no significant cementing material. Induration is because of compaction and partial recrystallization of kaolinitic matrix. Compaction has produced distortion and bending of mica flakes. Mica grains have been bent and crimpled, conforming to the outlines of the stronger grains, e.g. quartz. This has resulted into irregular shapes of mica grains and they occupy the interstitial spaces between framework grains. Recrystallization of matrix has produced larger kaolinite grains, some of which are also molded and oriented around the framework grains.

(2) *Kaolinitization*—It is the most important diagenetic process, affecting mica, felspar and chlorite grains. Kaolinitization is essentially a process of hydrolysis by which felspars and micas are altered to kaolinite under the influence of water containing dissolved carbon dioxide. The process takes place at low pH, i.e. acidic milieu under conditions where in the circulating water, concentration of dissolved ions and silica content is low.

Muscovite—Muscovite grains have been affected by kaolinitization and grains in different stages of alteration can be seen. In partially kaolinitized muscovite flakes patches



STAGE I

Quartz, rather fresh felspar, and mica embedded in a primary matrix Q-quartz, F-felspar, M-mica, P.M-primary matrix

STAGE II

Highly kaolinitized felspars. The boundary between primary matrix and altered felspar grains begins to disappear.

STAGE III

Completely kaolinitized felspars, leading to development of secondary matrix (S.M.).

Text-figure 2—Schematic development of secondary matrix due to alteration of felspar and mica grains.

of kaolinite are present. The optical orientation of neoformed kaolinite in the mica flakes is different than that of the host mica flake. In advance stages of kaolinitization, laths of kaolinite are visible in different orientation. The outline of muscovite grain is retained. In advance stages, even the boundary between grains and matrix is obliterated.

Biotite—Kaolinitization of biotite grains has produced a brownish mass of kaolinite crystals. Alteration of biotite causes expansion of crystal producing swollen biotite grains. Kaolinite crystals formed are in the form of twisting laths. Sets of laths are arranged at low angles to each other. Partly original micaceous structure is retained (Plate 5, Fig. 21). At high magnification kaolinite appears as patches of aggregates, developing between the cleavage traces (Plate 5, Fig. 22). During kaolinitization of biotite much iron is made free. Some iron oxide is present as small grains scattered allover. Other part of the iron is present as pigment imparting brown colour.

Chlorite—Some chlorite grains are also seen altering to kaolinite. Green colour of chlorite is bleached.

Felspar—Original content of felspar was rather high (about 25-30%), which has mostly been kaolinitized, leaving behind only 10-15% unkaolinitized felspar. All the stages of kaolinitization are present.

In initial stages, kaolinite starts developing in patches all over the felspar grain. In next stage, a pseudomorph of kaolinite after felspar is producded. Boundary of the felspar grain is distinct, traces of cleavage are seen, and partially twinning laminae are also visible (Pl. 6, Fig. 23). In advanced stage, felspar grain loses its identity and contributes to matrix. Such grains appear as broad patches of matrix making gapsi n the framework of detrital grains. Within an altered felspar grain kaolinite crystals are randomly oriented (Pl. 6, Fig. 24). If recrystallized, they appear as large worm-like grains.

Kaolinitization of felspar has been selective. Microline seems to be least susceptible, as most fresh felspar grains are always microcline. Orthoclase and sodic plagioclases have been kaolinitized up to an extent of unidentifiability.

(3) *Secondary overgrowth of quartz*—In all the samples, quartz grains often exhibit development of some secondary overgrowth in the form of minor projections and thin rim of secondary quartz around a detrital quartz grain. These features have been studied by scanning electron microscope, and discussed at length by Singh (1974a). Source of silica for secondary overgrowth has been the silica released during kaolinitization of felspars and ferromagnesian minerals.

The diagenetic changes in the sandstone can be summed up as follows:

Compaction—moderate to strong, bending of mica flakes, recrystallization of kaolinite.

Felspar alteration—rather strong, to kaolinite.

Mica and chlorite alteration—strong, to kaolinite.

Secondary quartz overgrowth—little.

DISCUSSION

Mineralogical composition of Barakar sandstone is typically of an arkose. More precisely, it can be termed arkose wacke because of significant content of matrix (William, Turner & Gilbert, 1954). Felspars are important constituents of Barakar sandstone. Microcline is most abundant, followed by some orthoclase and sodic platioclases. Most of the arkoses contain characteristically potassic and sodic felspars, especially the microcline (Pettijohn, Potter & Siever, 1972). High content of felspar in a sediment suggests a high relief and rigorous erosion in the provenance of granite and gneissic rocks. Alteration of felspars started in the provenance. Most of the plagioclases were destroyed; thus only partly altered sodic plagioclases, orthoclase and microcline were transported to the place of deposition. During diagnesis felspars were further altered.

Fine-grained kaolinitic matrix is final product of extensive chemical weathering. Its association with fresh felspar grains suggests that violent mechanical erosion and very strong chemical weathering were simultaneously active in the source area (see KRYNINE, 1950). Abundance of felspar and presence of metamorphic rock fragments imply existence of large areas of coarse-grained quartzo-felspathic parent rocks, e.g. granites, gneisses, and medium grade schists. Such rocks usually constitute crystalline basement. Archean crystalline basement rocks are present around the Korba basin. These rocks have served as source rocks for the sediments of Korba Coalfield.

Angularity of detrital grains, bad sorting, high felspar content, monomineralic clay mineral matrix point to a quick and short distance transport as well as quick deposition of the material.

Composition of all the sandstones in this succession is very similar. This fact supports the contention that throughout the deposition of the sequence of Korba Coalfield similar rocks served as source rock in the provenance. This also implies that through time, during deposition of Barkar sediments in Korba Coalfield, a similar drainage and river system was present and continuously brought the material into the basin of deposition.

During post-depositional history of the Barakar sands, diagenesis caused compaction, recrystallization of kaolinitic matrix, kaolinitization of felspars, mica, and chlorite, development of secondary overgrowth of quartz, and precipitation of iron oxide in minor amounts as cementing material.

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EXPLANATION OF PLATES

PLATE 1

1. Sample no. 142. Fraction >1.0 mm. Angular metamorphic rock fragments, few fragments of quartz vein. Scale—one small div.=0.5 mm.
2. Sample no. 142. Fraction 1.0-0.6 mm. Angular rock fragments and clean, angular quartz grains. Scale—one div.=0.5 mm.
3. Sample no. 142. Fraction 0.6-0.3 mm. Angular rock fragments and quartz grains. Scale—one div.=0.5 mm.

PLATE 2

4. Sample no. 117. Fraction >1 mm. Subangular to subrounded grains, few grains are up to 3.0 mm in size. Scale —one small div.=0.5 mm.
5. Sample no. 117. Fraction 1.0-0.6 mm. Most of the quartz grains are subangular. Felspar fragments are also seen. Scale—one div.=0.5 mm.
6. Sample no. 117. Fraction 0.6-0.3 mm. equidimentional quartz grains, subangular to angular. Scale—one div.=0.5 mm.
7. Sample no. 100. Fraction >1.0 mm. Subrounded to subangular quartz grains. Few grains are dark coloured. Scale—one small div.=0.5 mm.
8. Sample no. 100. Fraction 1.0-0.6 mm. Subangular quartz grains. Scale—one div.=0.5 mm.
9. Sample no. 100. Fraction 0.6-0.3 mm. Angular quartz grains. Some quartz grains show black coating, some are milky in nature. Scale—one div.=0.5 mm.

PLATE 3

10. Sample no. 77. Fraction >1.0 mm. Subangular quartz grains, few rock fragments. Scale—one small div.=0.5 mm.
11. Sample no. 77. Fraction 0.6-0.3 mm. Dominantly angular quartz grains. Scale—one div.= 0.5 mm.
12. Sample no. 55. Fraction >1.0 mm. Angular quartz grains, majority are black in colour. Scale —one small div.=0.5 mm.
13. Sample no. 55. Fraction 1.0-0.6 mm. Subrounded quartz grains, some are shinning. Scale—one div.=0.5 mm.
14. Sample no. 14. Fraction >1.0 mm. Subangular quartz grains, few rock fragments. Scale—one small div.=0.5 mm.
15. Sample no. 14. Fraction 1.0-0.6 mm. Subangular quartz grains, few rock fragments. Scale —one div.=0.5 mm.

PLATE 4

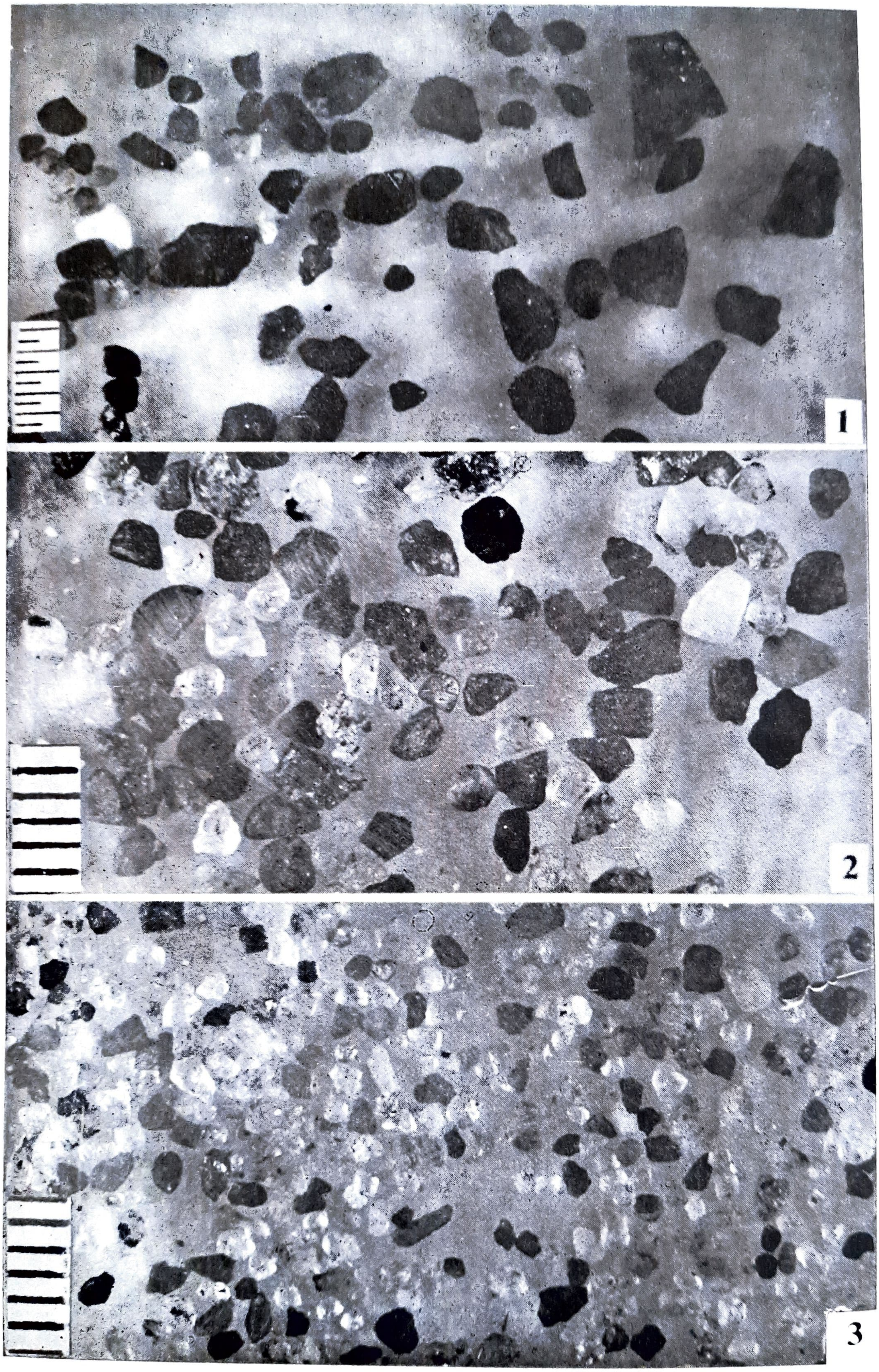
16. Thin section showing quartz grains and a microcline grain. X-nicols. Sample no. 50. Magnification—68 ×.
17. Thin section showing framework grains, i.e. quartz, felspar and mica, embedded in matrix. Sample no. 9. Magnification—68 ×.
18. Thin section showing primary matrix (P. M.) surrounding the quartz grains. On the left hand side, the felspar grain is seen partially altered into kaolinite. Sample no. 50. Magnification—97 ×.
19. Thin section showing quartz grains embedded in primary matrix (P.M.) and development of secondary matrix (S.M.) due to alteration of felspar and mica. Q—quartz, F—felspar. Sample no. 83. Magnification—97 ×.

PLATE 5

20. Thin section showing bent biotite flake. Q—quartz, F—felspar, partially kaolinitized. Sample no. 57. Magnification—97 ×.
21. A biotite flake partially changed into kaolinite. Q—quartz, P. M.—primary matrix. Sample no. 85. Magnification—150 ×.
22. An advanced stage of kaolinitization of biotite. The cleavage traces are still visible. Along the cleavage planes, kaolinite aggregates have developed. K—kaolinite. Sample no. 64. Magnification—258 ×.

PLATE 6

23. Felspar altering into kaolinite and producing secondary matrix. Q—quartz, F—partially altered felspar, S. M.—secondary matrix produced due to alteration of felspar. Sample no. 83. Magnification—150 ×.
24. Felspar grain completely altered into kaolinite. The grain is made up of various types of kaolinite aggregates. Q—quartz, F—altered felspar grain. Sample no. 83. Magnificaion—370 ×.
25. Secondary matrix showing kaolinite aggregates in various stages of crystallization. Some of the aggregates are rather coarsely crystallized. Sample no. 64. Magnification —258 ×.
26. A close view of the worm-like kaolinite aggregates in secondary matrix. Sample no. 64. Magnification—675 ×.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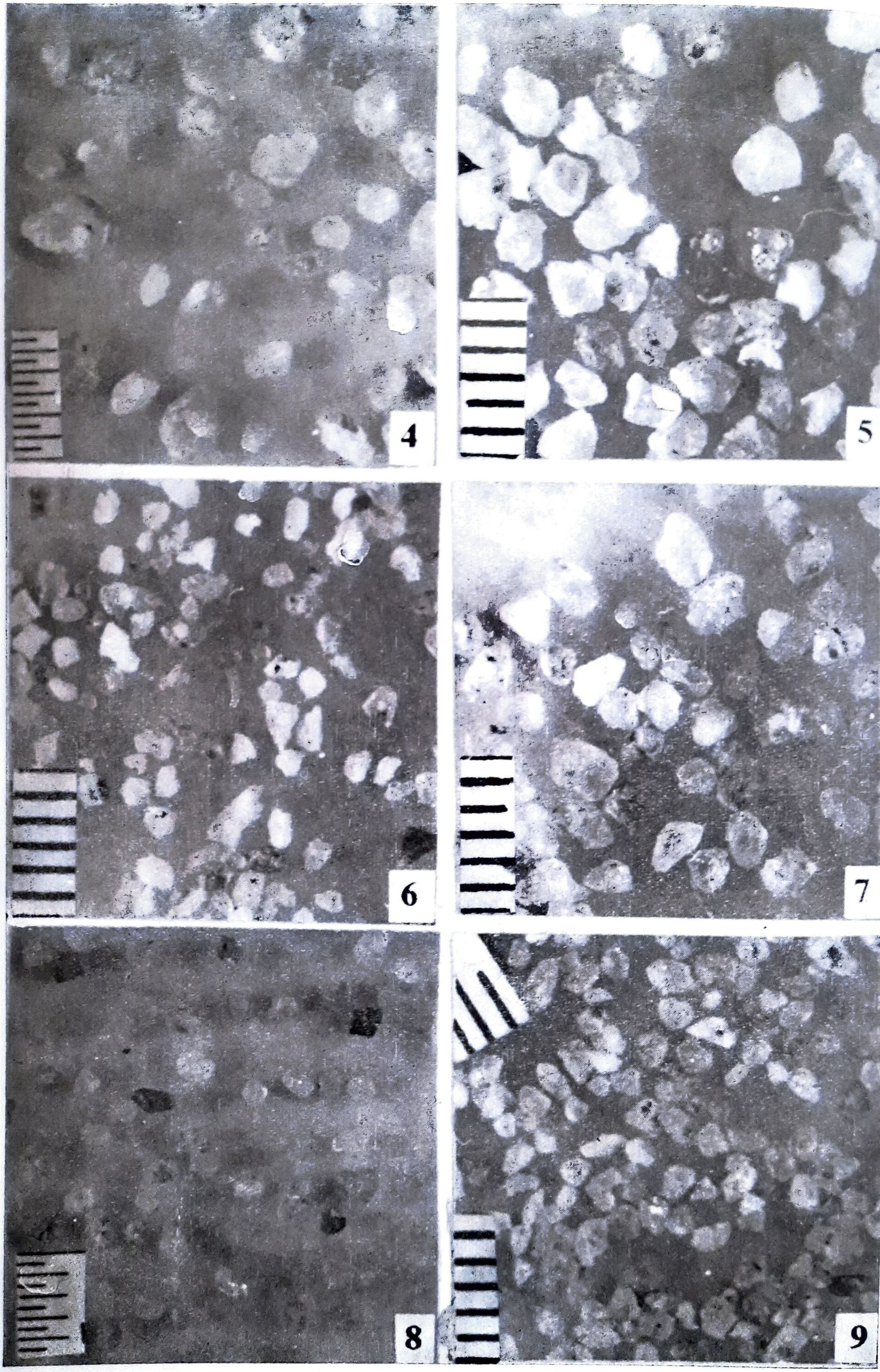

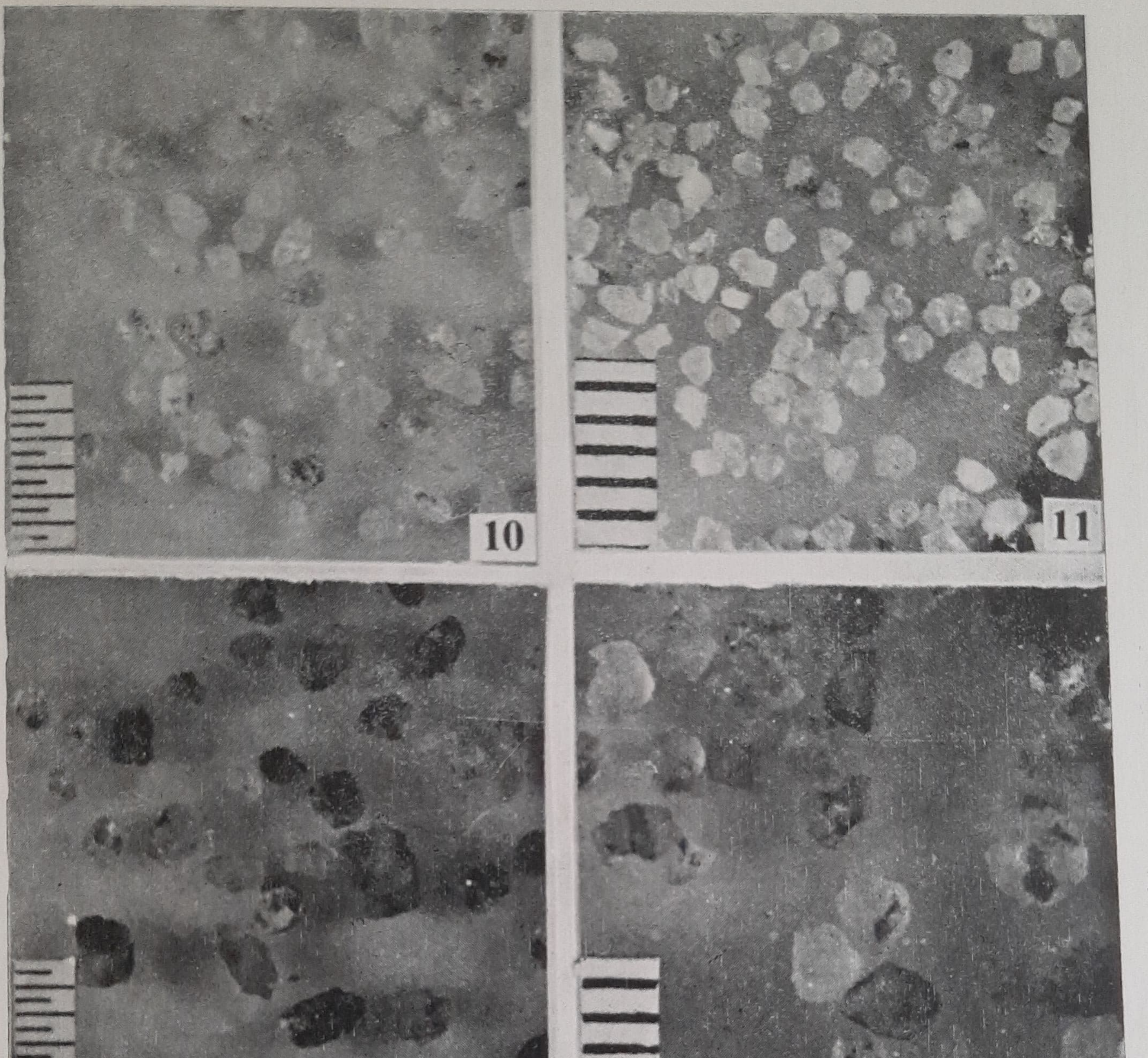
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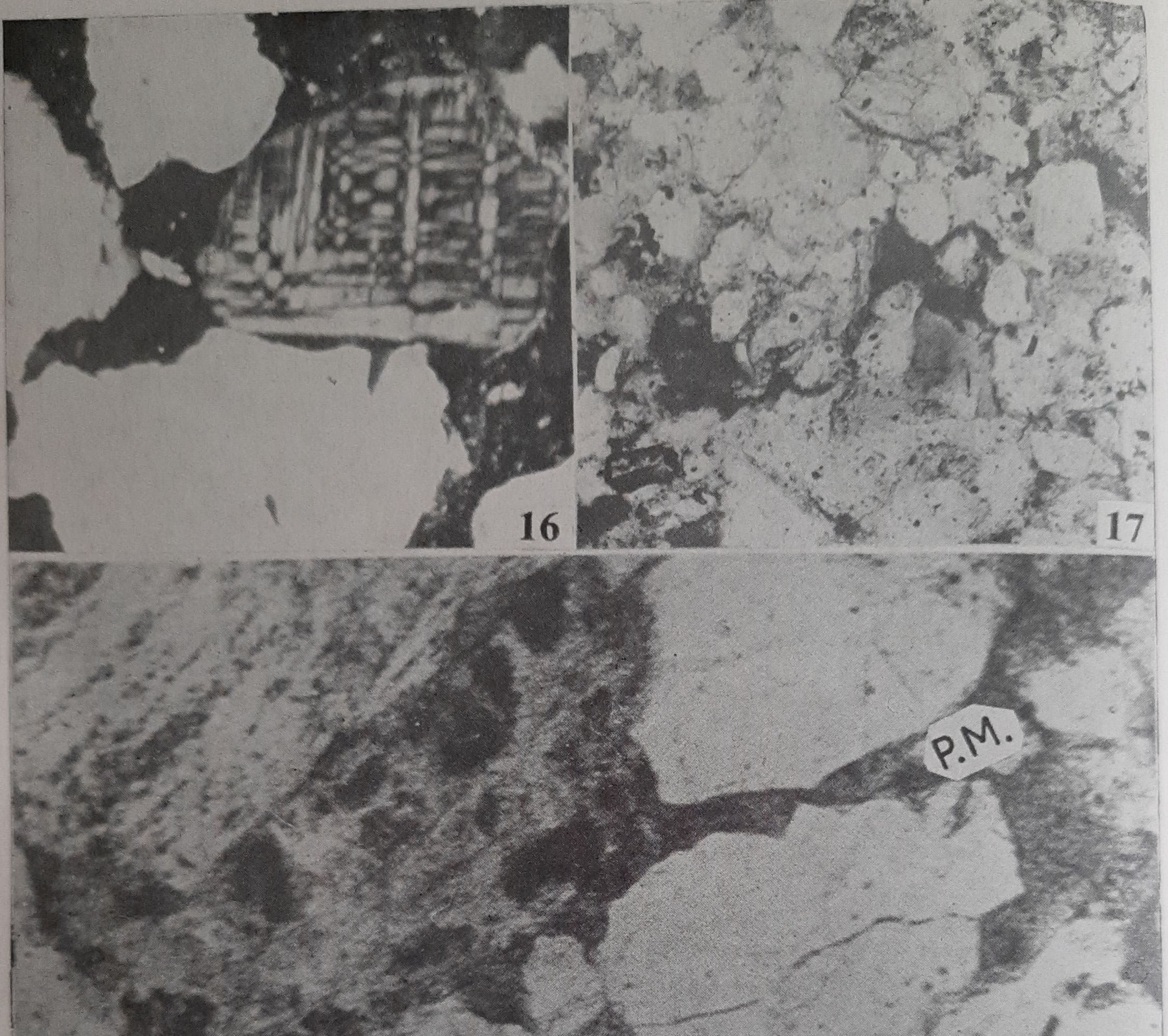
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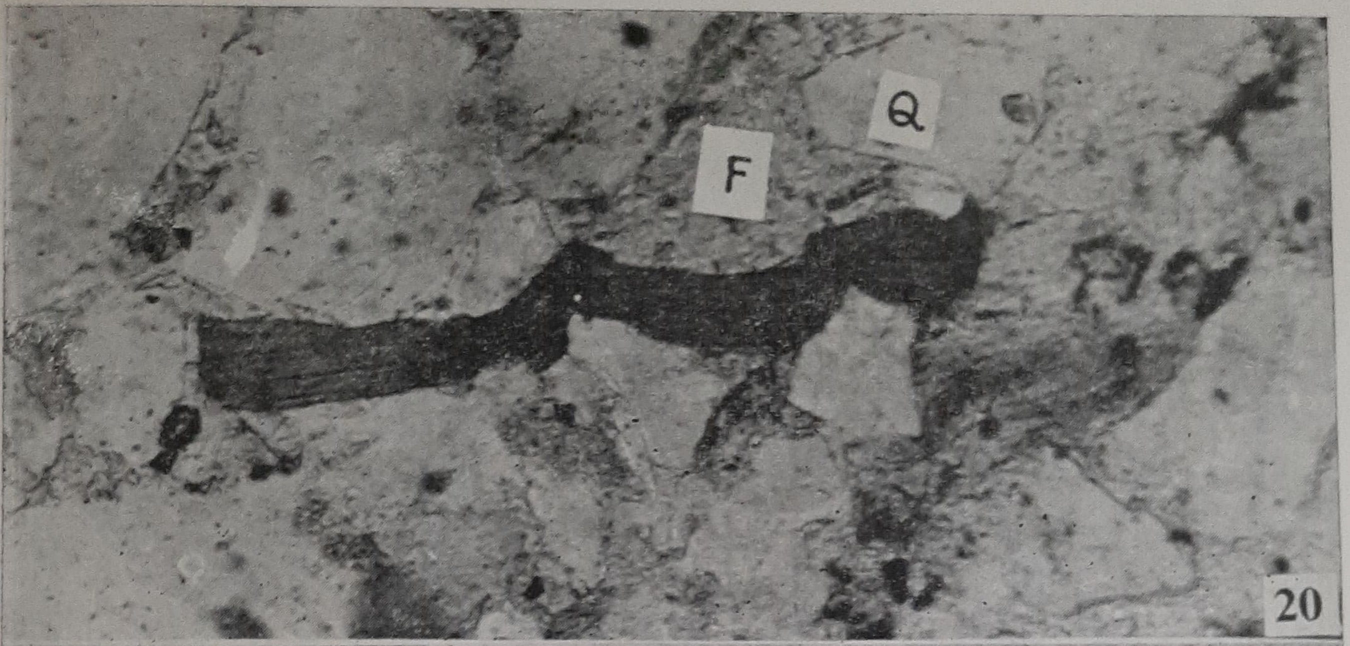
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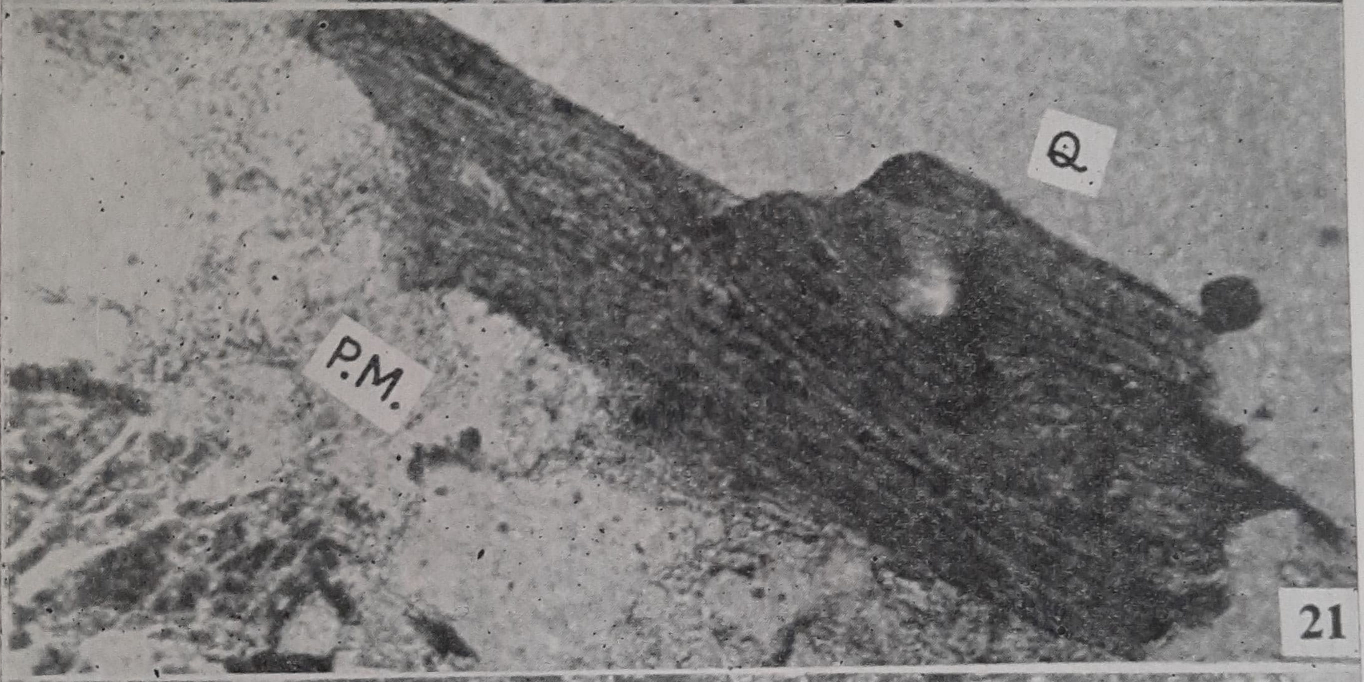
Q
P.M.
21


K→
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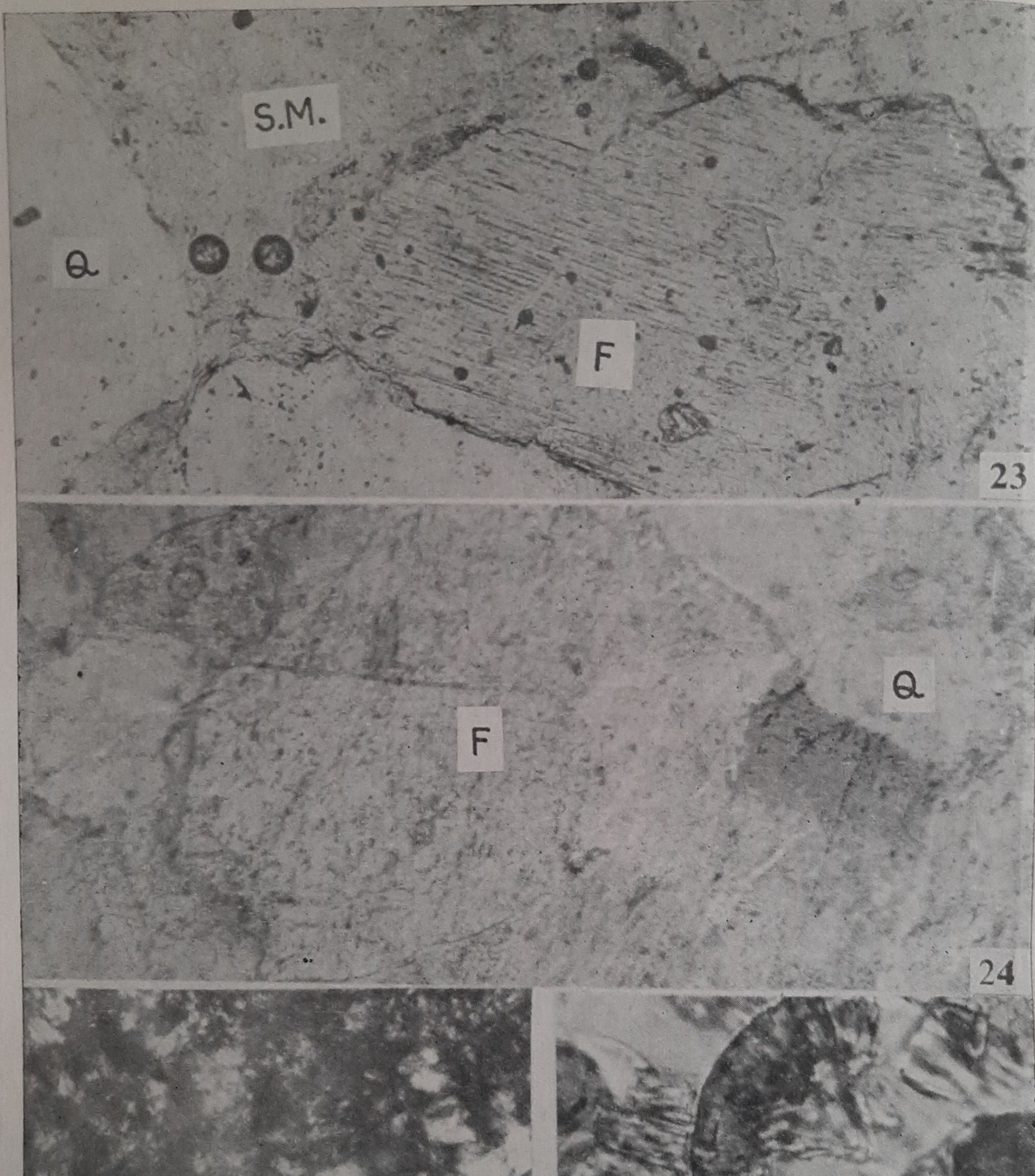
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Q
F
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