9. SEDIMENTARY ROCKS OF THE JAN-MAYEN RIDGE

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INTRODUCTION

On cruises 10 and 15 of *Academic Kurchatov* (1971, 1973) at the Jan-Mayen Ridge, (Figure 1) a large number of samples was obtained. Most of them contained sedimentary rocks (Table 1). The data obtained, along with the absence of linear magnetic anomalies, indicate that for the Jan-Mayen Ridge, sedimentary, not volcanic rocks, are the significant lithology.

Laboratory studies of the samples indicate that the sedimentary rocks are represented by compact, well-cemented types, which were subjected to metamorphism and converted into shales. This metamorphism, evidently, seems to explain the failure to drill basaltic basement on the Jan-Mayen Ridge during DSDP Leg 38. Only in Hole 350 were basalts penetrated. At Sites 346, 347 and 349, the drilling was terminated in hard sedimentary rocks.

DESCRIPTIONS OF THE SEDIMENTARY ROCKS

Petrologic and petrographic data, as well as chemical data, indicate the following sedimentary rock varieties: (1) phosphatic-ferruginous calcareous siltstones, (2) volcanic-terrigenous quartz-feldspathic micaceous gravelly sandstones, (3) phosphatic clay micaceous hydromicaceous argillites with pyroclastics, (4) limestones and chalk-like limestones, (5) phyllitized chloritic clayey shales, and (6) manganous ferruginous rocks.

Volcaniclastic-Terrigenous Gravelly Sandstones (Station 799-1, Sample No. 11a)

The samples consist of small samples (up to 10 × 6 × 3 cm) with brown-green fresh fractures. Basalt rubble is present, as well as rare angular volcanic glass fragments. The sand fraction consists of rounded and angular basalt fragments, hyalobasalts, palagonized basalt, glass, grains of plagioclase, pyroxenes, quartz, magnetite, colorless acid volcanic glass, foraminifera, and rare olivine. Pyritization and quartz-calcite veinlets are noted.

Quartz-Feldspathic Sandstones (Station 799-1, Sample No. 1; Station 801, Sample No. 14)

The samples are angular, small fragments (8 × 4 × 4 cm). Microscopic study indicates two sandstones varieties, based on the cement composition: carbonate bearing or calcareous-ferruginous clay. The sandstones are fine-grained, fissile, and are massive. The calcareous-ferruginous clayey sandstones consist of angular to poorly rounded fragments of plagioclase (20%-30%), quartz (20%-30%), calcitic detritus (15%-20%), and ore minerals (5%-10%). Sometimes lenticular veinlets of quartz with calcite are observed. The cement is microgranular, consisting of brown ferruginous calcareous clay.

Calcareous sandstones are distinguished by their calcareous cement and microcrystalline structure. In the fragmental fraction, plagioclase (50%-55%) and quartz (40%-45%) dominate. Corrosion and replacement of the quartz grains by calcite is noticeable.

Siltstones (Stations 799-1, 799-2, 800)

Siltstones are present as angular samples, with a greenish-yellow fresh fracture. The pebble and sand fractions usually consist of angular, or subrounded fragments of basalts, hyalobasalts, and volcanic glass.

The silt fraction has a variable composition: basic plagioclases (to 60%), quartz grains (to 20%), and biotite and muscovite are also present (up to 20%). The presence of green biotite characterizes the silt fraction. There are also grains of glauconite, hornblende, tourmaline, zircon, and rutile. Some samples contain acid and basic pyroclastics (up to 10%). At Station 800 (Sample No. 1) single pyroclastic interbeds, with thickness up to 1 cm, are present. The pyroclastics are mainly represented by isotropic, transparent acid glass. Glassy particles are round or drop-like, and are enclosed by a fine membrane with a hydrogoethitic composition. The cement is a brown ferruginous material.

The siltstones with pyroclastic interbeds are appreciably enriched in Fe_2O_3, TiO_2, and MnO (Table 2, Sample No. 2). There is no doubt, that volcanic material is the source of the increased concentration of these elements, as hydrothermal activities will cause ferruginization and manganization. The siltstones and other sedimentary rocks of the Jan-Mayen Ridge contain veins and lenses of brown-black oxides (iron and manganese) with thicknesses up to 10-15 cm. The manganese content, in the interbeds and in the siltstones, ranges considerably and shows no correlation with the iron content (Table 2, Sample Nos. 2, 3). In some siltstone samples, silica is abundant, because of the increased content of quartz and mica.

Phosphatic Siltstone (Station 799-2, Sample No. 11)

Recovered were plain, angular samples measuring up to 10 × 8 × 3 cm. Sandy silty grains are represented by angular, poorly rounded fragments of feldspar (60%-70%), quartz (10%-15%), basalt (3%-5%), brown volcanic glass (2%-3%), single grains of zircon and glauconite, and flakes of muscovite (2%-3%) and biotite (2%-3%). A phosphatic clay material is the cement, in which barely distinguishable globules are dispersed.

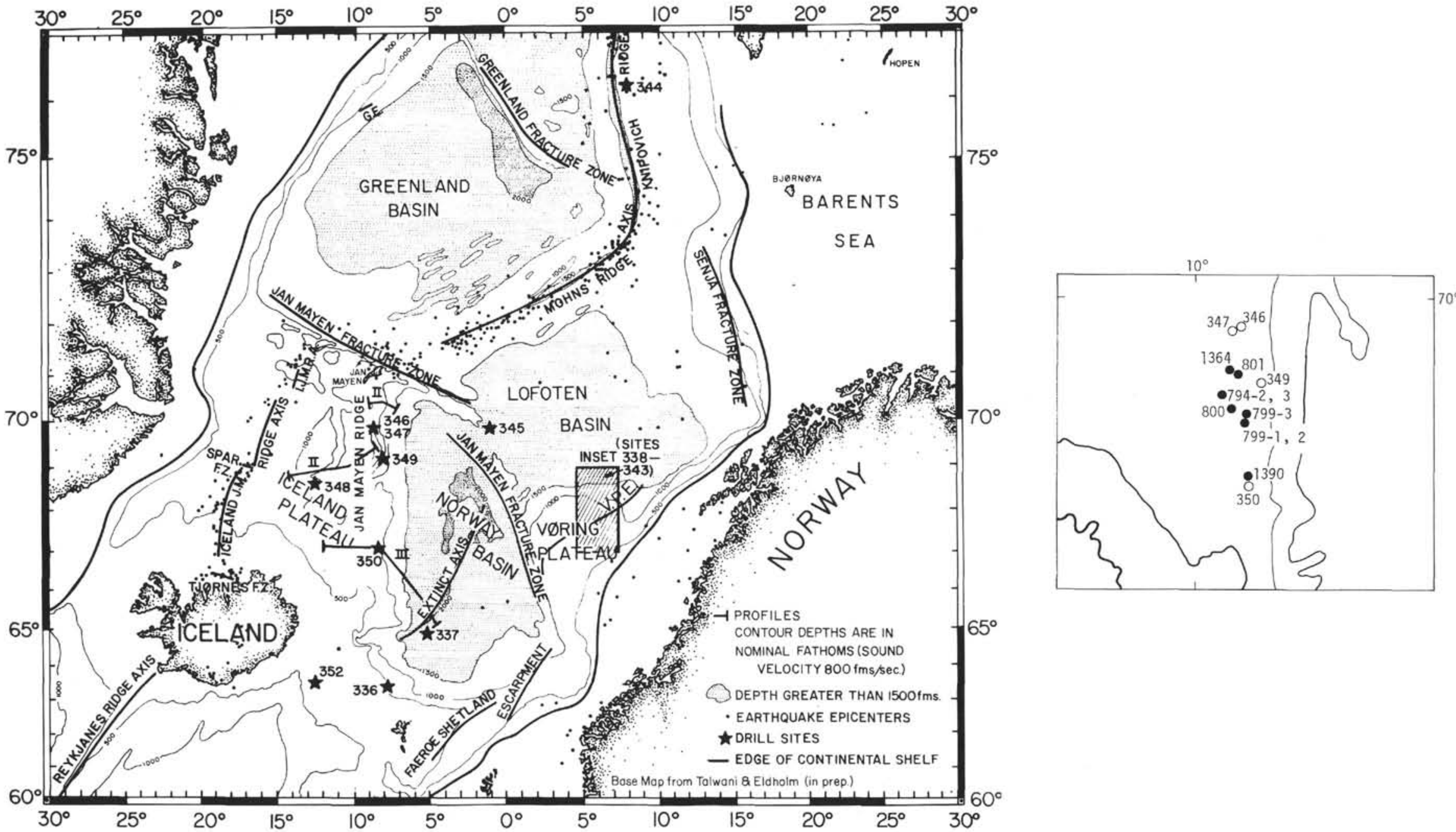

Figure 1. *Distribution of dredge stations (black circles) of cruises 10 and 15 of the R/V* Academic Kurchatov *(1971, 1973) and sites (white circles) of* Glomar Challenger *DSDP Leg 38 (1974) on the Jan-Mayen Ridge.*

TABLE 1
Locations and Characteristics of Dredged Sedimentary Rock Samples from the Jan-Mayen Ridge

Station and Sample Number	Position	Depth (m)	Characteristics
Station 794-3	68° 28.0 N		Phyllitized clayey shales
Sample 16	09° 25.0 W	1700	
	68° 26.0 N		
	09° 32.0 W	1400	
17	09° 32.0 W	1400	Micaceous argillites
Station 799-1	68° 03.0 N		
Sample 7	08° 33.5 W	1870	Argillo-chloritic shales
	68° 04.3 N		
	08° 32.0 W	1380	
10	08° 32.0 W	1380	Calcareous siltstones
10a	08° 32.0 W	1380	Foraminiferal limestones
11a	08° 32.0 W	1380	Volcanic-terrigenous gravelly sandstones
12	08° 32.0 W	1380	Hydromicaceous argillites
13	08° 32.0 W	1380	Argillo-chloritic silty shales
16	08° 32.0 W	1380	Manganous-ferruginous
Station 799-2	68° 05.8 N		
Sample 10	08° 30.1 W	1026	Calcareous silty micaceous shales
	68° 05.3 N		
	08° 26.3 W	960	
11	08° 26.3 W	960	Phosphatic argillite
11a	08° 26.3 W	960	Phosphatic siltstones
15	08° 26.3 W	960	Ferruginous
Station 800	68° 08.5 N		
1	09° 10.0 W	1976	Ferruginous pyroclastic siltstone
	68° 16.0 N		
	09° 03.0 W		
Station 801	68° 45.0 N		
Sample 8	08° 57.5 W	1900	Foraminiferal sandy limestone
	68° 50.0 N		
	08° 42.8 W	950	
Station 801	68° 45.0 N		
Sample 12	08° 57.5 W	1900	
	63° 50.0 N		
	08° 42.8 W	950	Silicified limestone (chalk with chalcedony)
13	08° 42.8 W	950	Hydromicaceous argillite with volcanic ash
14	08° 42.8 W	950	Quartz-feldspathic sandstone
Station 1364	68° 50.83 N	1540	Siltstone
Sample	08° 56.30 W		
	68° 51.38 N	1200	
	08° 56.05 W		
1A	08° 56.05 W	1200	Argillite
Station 1390	67° 03.17 N		
Sample 1	08° 21.33 W	1600	Siltstone
	67° 04.08 N		
	08° 18.70 W		
1A	08° 18.70 W	1600	Argillite

The composition of the cement allows the distinction between the calcareous, ferruginous siltstones and phosphatic siltstones. In the former, the cement is calcitic; in the latter, it is ferruginous-hydrogoethitic, with a large clay admixture.

Argillites (Stations 794, 799-1, 799-2, 801)

These are well-developed on the Jan-Mayen Ridge. They are present with a variable quantity of pebble, sand, and silty material. There are transitional varieties (from argillites to siltstones). The content of rubble in some argillites is so high that they might be classified as gravelly argillites. Jointing is characteristic of argillites and siltstones. The argillites have a definite joint system with three joint patterns being especially clear: the first coincides with obscure bedding, that is weakly inclined or horizontal; the second is present at an angle of 60° with the first; and the third is nearly perpendicular to the first, or nearly vertical. On the whole, because of the clear development of these three joints, the samples often look like bevelled prisms. It is interesting to note that membranes and fine incrustations of ferromanganous hydroxides, fine quartz crystals, and chloritoid masses develop on the joint faces. The argillites have yellow-green and brown-green colors. On the weathered surfaces, ferromanganous membranes and incrustations developed.

TABLE 2
Chemical Composition (Wt. %) of Sedimentary Rocks From the Jan-Majen Ridge

	1	2	3	4	5	6	7	8
SiO_2	30.14	42.81	58.36	56.62	52.04	19.77	55.94	12.82
TiO_2	0.72	2.38	1.36	1.30	0.76	0.72	1.15	0.25
Al_2O_3	17.00	16.02	16.68	17.45	9.25	7.55	17.76	3.46
Fe_2O_3	4.62	20.13	5.96	8.98	22.96	4.55	8.40	–
FeO	1.33	0.06	1.33	0.66	0.04	0.98	1.04	–
MnO	0.17	1.07	0.13	0.16	0.40	0.38	0.08	0.09
MgO	1.58	3.29	2.64	2.83	3.62	2.50	3.40	3.84
CaO	19.23	1.11	1.55	1.13	0.56	33.11	1.07	39.29
Na_2O	5.52	4.23	5.31	2.08		2.10	4.76	3.34
K_2O				2.88		1.30		
P_2O_5	10.28	0.38	0.15	0.26	0.16	0.35	0.15	0.14
F	1.16	–	–	–	–	–	–	–
LOI	8.46	8.51	6.38	6.15	6.75	25.49	6.14	34.01
H_2O	2.30	4.70	2.91	–	5.23	0.57	4.33	1.10

Note: 1 = Phosphatic argillite, Station 799-2, Sample No. 11; 2 = Ferruginous siltstone with volcanic ash, Station 800, Sample No. 1; 3 = Slightly ferruginous siltstone, Station 799-1, Sample No. 12; 4 = Argillo-chloritic, slightly ferruginous shale, Station 799-1, Sample No. 13; 5 = Ferruginous argillite, Station 801, Sample No. 13; 6 = Sedimentary breccia, Station 770, Sample No. 6; 7 = Slightly ferruginous argillite, Station 799-1, Sample No. 13-a; 8 = Limestone, Station 793-2, Sample No. 3. Analyst: J. A. Dubrovskia

The pebble fraction consists of round to angular fragments and blocks of basalts, granites, gneisses, quartzites, limestones, and sandstones. Sandy and silty grains consist of feldspar, quartz, pyroxene, hornblende, epidote, and mica flakes (biotite and muscovite). Angular particles of hyalobasalts, volcanic glass, black cloudy glass, and palagonite are abundant. According to the diffraction data, the clay fraction consists of amorphous material, hydromica, chlorite, and montmorillonite. Secondary minerals are represented by chlorite, calcite, quartz, hydrogoethite. The chlorites are green and slightly anisotropic or isotropic. They form embryonal mantles around the fragments of basalts and palagonites, and also form fine veins. Rose-like and prismatic crystals of calcite are present, but rare. Quartz is present as fine veins and crystalline forms on the joint faces.

Phosphatic Argillites (Station 799-1, Sample No. 11)

Plain samples are angular, measuring up to 20 × 15 cm. In comparison with the nonphosphatic argillites, the phosphatic ones are firm, thick, and hard. Their weathered surface is yellow-gray, while fresh fractures are darker. Traces of "rock borers" were observed on the sample surfaces. The texture is silty-clayey, and their bedding is obscure. Silty and sandy particles occupy 10%-15% of a thin section area. They consist of flat, angular grains of plagioclase (50%-60%), angular and rounded quartz grains (40%-50%), biotite flakes (2%-3%), muscovite flakes (1%-2%), single grains of monoclinic pyroxene, hornblende, zircon, zeolites (?), and greenish-yellow volcanic glass. Rare organic components are present, appearing similar to the nucleus of foraminifera or ferruginous Radiolaria. Glauconitized biotite is present. Isotropic phosphate is present in concretions with clay minerals, and appears like fine, widely dispersed, round-shaped emanations. With an index of $N=1.602$, the phosphatic clay mass is similar to kurskite. X-ray diffraction data indicate that the phosphatic argillite consists of quartz, hydromica, kaolinite, and chlorite. P_2O_5 content in argillite is 10.28% (Table 2, Sample No. 1).

Calciferous Argillites (Station 799-1, Sample No. 10)

These are present as some small (up to 5 × 3 × 0.5 cm) plain, angular fragments with a light-gray color. Their texture is silty, the structure is massive. The silt fraction consists of poorly rounded angular quartz grains (50%-60%), table-like and angular grains of plagioclase (40%-50%), single grains of glauconite, hydrogoethite, and flakes of muscovite and chlorite. The cement is calcareous.

Limestones and Chalk-like Limestones (Stations 770, 799-1, 801)

This rock type is not abundant. In outward appearance, they are similar to siltstones, but differ in their light-gray and white color, sometimes in their chalk-like composition. Compositionally, the following varieties exist: silicified, sandy, foraminifera, and coral limestones. Chalk-like silicified limestones (Station 801, Sample No. 12) possess a pelitomorphic structure and laminated texture, and contain rare foraminifera fragments, partially replaced by chalcedony. Chalcedony interbeds and lenticules, with a thickness up to 1 cm, are present.

Sandy Foraminiferal Limestones (Station 801, Sample Nos. 8, 11; Station 770, Sample No. 1)

The rocks are transitional to sandstones and siltstones. The content of their sandy and silty fractions increases to 40%. The mineral composition of these fractions is as follows: quartz (40%-50%), biotite (1%-2%), and biogenous calcareous components (up to 8%). Quartz and plagioclase grains are corroded and replaced by calcite. Samples from Station 770 contain rounded rubble and angular fragments of granites, gneisses, quartzites, basalts, and other rocks.

Two limestone varieties are noted: coral and foraminiferal. The former consists of colonial coral components (60%-70%), mollusk shells (about 10%), and calcareous biogenous components of unknown genesis (Station 801, Sample No. 12a). The cement is fine-grained and calcareous.

Chloritic Shale (Station 799-1, Sample Nos. 7, 13)

This type was found during dredging on the western slope of the southern part of the Jan-Mayen Ridge. Shales are represented by small (no more than 10 × 5 × 3 cm) plain angular fragments and rubble with sharp rims. From one dredging at the base of the seamount about 100 fragments were gathered.

The shales have aleuropelitic and blastopelitic structures. The content of silt fraction ranges from 10%-15% to 30%-35%. Feldspars, represented by twinned tablets of plagioclase, are abundant in the silty fraction (up to 50%-60%). Quartz (up to 30%-40%) forms isometric grains. There are also muscovite fragments (up to 3%-5%), fine single prisms of rhombic pyroxene (hypersthene), particles of hydrogoethite (5%-8%), calcite crystals (up to 3%), and round inclusions of fine chalcedony. The cement, with a chloritic composition, develops around the mineral grains. The clay fraction consists of fine-grained scaly-shaly mass of chlorite. Chemical data (Table 2, Sample No. 4) show an increased content of SiO_2 (56.6%) and K_2O (2.9%). The ratio of K_2O to Na_2O is 1.4, evidence of continental source.

Phyllitized Clayey Shales (Station 794-3, Sample No. 16)

These were recovered on the western mount slope not too far north from the previous station (Figure 1). Shale forms 20% (10 kg) of the dredged material. Basalt is also abundant. Plain, angular fragments of shales measure 10 × 5 × 4 cm to 15 × 8 × 6 cm. A fine ferruginous and manganous membrane irregularly develops on the surface. Their weathered surface is yellow-green, their fresh fracture is dark gray. The texture is silty-clayey, with a shaly texture.

The silty fraction is represented by acid and intermediate plagioclase (20%-30%), rounded quartz grains (5%-10%) with a wavy extinction, flakes of hydrotizated biotite (10%-15%), muscovite (1%-2%), particles of iron hydroxides (5%), and single calcite grains. Clay minerals (50%-60%) are often formless, with a slight pleochroism, greenish-yellow color microfoliaceous, with cleavage relicts.

SUMMARY AND CONCLUSION

Foraminifera, corals, and fragments of other fauna are present in the sedimentary rocks from the Jan-Mayen Ridge. As a rule, their preservation is poor, therefore, all attempts to define the specific composition of fauna were unsuccessful. In an indirect way, the age of sedimentary rocks of the Jan-Mayen Ridge can be defined by the results of Leg 38.

According to the character of strata, the dredged samples are present lower in the geologic column, and lower hypsometrically than the strata drilled during Leg 38. Therefore, one can distinguish these sedimentary rocks as older than the rocks present in the Leg 38 sites. For example, the rocks from Stations 800 and 801 are older than late Eocene, in which Site 349 terminated. Comparing the degree of metamorphism, which is dependent on the age of the rock, one can conclude that the shales of Stations 794-3 and 799-1 are the oldest rocks among the material obtained. Their exterior is similar to the Paleozoic rocks of the British Isles and Scandinavia. The absence of fauna in the shales is further evidence of their ancient age. Tectonic loads are the cause of the lithification and metamorphism of the sedimentary rocks. Schist-forming processes, phyllitization, and joint development also were the results of these loads. Lithification may be a result of the hydrothermal replacement, which forms in some areas the phosphatic, ferruginous, manganous, and calcareous rocks.

It is safe to assume that the rocks of the Jan-Mayen Ridge were, at first, subjected to subsidence to a considerable depth, and then uplifted to their contemporary position, by the ascending tectonic movements. Thus, the Jan-Mayen Ridge is in contrast to other Atlantic submarine ridges, not only in the sedimentary rock composition, but in the character of the tectonic movements.