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Particle Size and X-Ray Analysis of

Feldspar, Calvert, Ball, and Jordan Soils

By

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16. Abstract

Pipette analysis and X-ray diffraction techniques are employed to characterize the particle size distribution and clay mineral content of the Feldspar, Calvert, Ball, and Jordan soils. In general, the Ball, Calvert, and Jordan soils are primarily clay size particles composed of Kaolinite and Illite whereas the Feldspar soil is primarily silt-size particles composed of Quartz and Feldspar minerals.

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PARTICLE SIZE AND X-RAY ANALYSIS OF FELDSPAR, CALVERT, BALL, AND JORDAN SOILS

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SUMMARY

By using pipette analysis and X-ray diffraction techniques, the particle size distribution and clay mineral content of the Feldspar, Calvert, Ball, and Jordan soils are investigated. The results show the Ball, Calvert, and Jordan soils are primarily clay-size particles composed of Kaolinite and Illite. The Feldspar soil, however, is primarily silt-size particles composed of Quartz and Feldspar minerals.

INTRODUCTION

Interest in environmental monitoring has led to research involving the remote sensing of suspended sediments in rivers, estuaries, and the oceans. Currently, studies are underway to define the potential of remote sensing for identifying and monitoring Feldspar, Calvert, Ball, and Jordan clay types of sediments. It is the purpose of this report to characterize the particle size distribution and clay mineral content of the Feldspar, Calvert, Ball, and Jordan soils using pipette analysis and X-ray diffraction techniques, respectively. These basic data are required to support both experimental and optical modeling studies being conducted at several research organizations.

PARTICLE SIZE ANALYSIS

Of the various methods used in particle size analysis of the less than 62μ fraction, pipette analysis is considered the simplest and most reliable. The technique of pipette analysis, which is based on the particle settling velocity as related to its diameter by Stocks law, is described in detail by Folk (ref. 1). By applying this technique to a sample of each of the four soils, cumulative size distributions were obtained as shown in figures 1-4.

By adopting the American Society for Testing Materials standard for particle size fractions, (table 1) the soils can be characterized by their percent sand, silt, and clay size material (ref. 2).

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Table 1. Particle Size Fractions

(ASTM, 1964)

Particle Size Fraction	Particle Size (mm)
Sand	0.074 - 4.76
Silt	0.005 - 0.074
Clay	<0.005

Referring to figures -4, the soils are characterized as follows:

Feldspar	< 2% Sand
	76% Silt
	22% Clay
Calvert	2% Sand
	18% Silt
	80% Clay
Ball	< 2% Sand
	12% Silt
	86% Clay
Jordan	4% Sand
	23% Silt
	73% Clay

CLAY X-RAY ANALYSIS

The general concept of X-ray diffraction analysis is covered well by Kuo and Cheng (ref. 3), however, the criteria for identification of clay minerals have been adopted from Schultz (ref. 4) and Carrol (ref. 5). In applying these criteria, the subsequent analysis is restricted to the specific clay minerals Kaolinite, Illite, Chlorite, and Montmorillonite due to their abundance and importance; and to a general classification, namely, mixed-layered clays.

(NOTE: Criteria for identification should come before preparation and treatment of samples.)

CRITERIA FOR IDENTIFICATION

Kaolinite exhibits a first-order peak at 7A° which when heat-treated at 550°C diminishes or collapses entirely.

Illite exhibits a first-order peak at 10A°.

Chlorite exhibits a first-order peak at 14A° which will often expand when heat-treated at 550°C.

Montmorillonite is characterized as having little response in the untreated state, however, it exhibits a 17A° peak when treated with ethylene glycol. When heat-treated at 180°C, the 17A° peak shifts to 9.8A° due to the volatilization of the ethylene glycol and absorbed water.

Mixed-layered clays are characterized as being interstratification of various clay minerals which exhibit broad peaks in the 10A° to 17A° range.

PREPARATION AND TREATMENT OF SAMPLES

Using the less than 2μ fraction from the particle size analysis, a slide mount of each soil was made using a smear technique. After drying at room temperature, the following treatments were applied in succession:

1. No treatment
2. Ethylene Glycol treatment
3. 180°C treatment
4. 550°C treatment

INTERPRETATION OF RESULTS

Feldspar

All four treatments indicated the presence of Montmorillonite, Chlorite, or mixed-layered clays in trace amounts. No significant differences in the four diffraction patterns were noted; thus, a single diffraction pattern than of the unheated sample is presented. However, under optical examination the vast majority of the samples were found to be Feldspar and Quartz, which conforms with the occurrence of the 6.4A° Feldspar peak (fig. 5).

Calvert

The untreated sample exhibited distinct 10A° and 7A° peaks (fig. 6). No significant change occurred with either the ethylene glycolor 180°C treatments (fig. 7 and 8). With the 550°C treatment, the 7A° peak collapsed (fig. 9). Thus, the primary clay minerals are Kaolinite and Illite.

Ball

The untreated sample exhibited 17A°, 10A°, and 7A° peaks (fig. 10). With the ethylene glycol treatment, the 17A° peak became more prominent which indicates the presence of Montmorillonite (fig. 11). With 180°C treatment, the 17A° peak apparently shifted to 9.8A° which also indicates the presence of Montmorillonite (fig. 12). When treated at 550°C, the 7A° peak collapsed which insures the presence of Kaolinite. No apparent increase in the 14A° occurred with the 550°C treatment, hence, the likelihood of Chlorite is small (fig. 13). Thus, the constituent clay minerals are Kaolinite, Illite, Montmorillonite, and some mixed-layered clays.

Jordan

The untreated sample exhibited strong 7A° and 10A° peaks, with weak 14A° and 17A° peaks (fig. 14). The ethylene glycol treated sample exhibited no expansion of the 17A° peak, hence, the likelihood of Montmorillonite is small (fig. 15). Similar results were obtained in the 180°C treatment (fig. 16); however, the collapse of the 7A° peak with the 550°C treatment indicates the presence of Kaolinite (fig. 17). Thus, the primary clay minerals are Kaolinite, Illite, and some mixed-layered clays.

CONCLUDING REMARKS

Utilizing pipette analysis and X-ray diffraction techniques, the particle size distribution and clay mineral content of the Feldspar, Calvert, Ball, and Jordan soils have been investigated. All soils have a low percentage of sand, and Feldspar has a high percentage of silt. The Ball, Jordan, and Calvert soils have a high percentage of clay size particles. Considering mineral content, the Feldspar soil is composed primarily of Feldspar and

Quartz minerals. Primary clay minerals in both the Calvert and Jordan soils are Kaolinite and Illite; however, the Jordan soil has some mixed-layered clays. The Ball soil is composed primarily of Montmorilloite, Kaolinite, Illite, and some mixed-layered clays. The results herein are a basic characterization and by no means completely describe the soils investigated.

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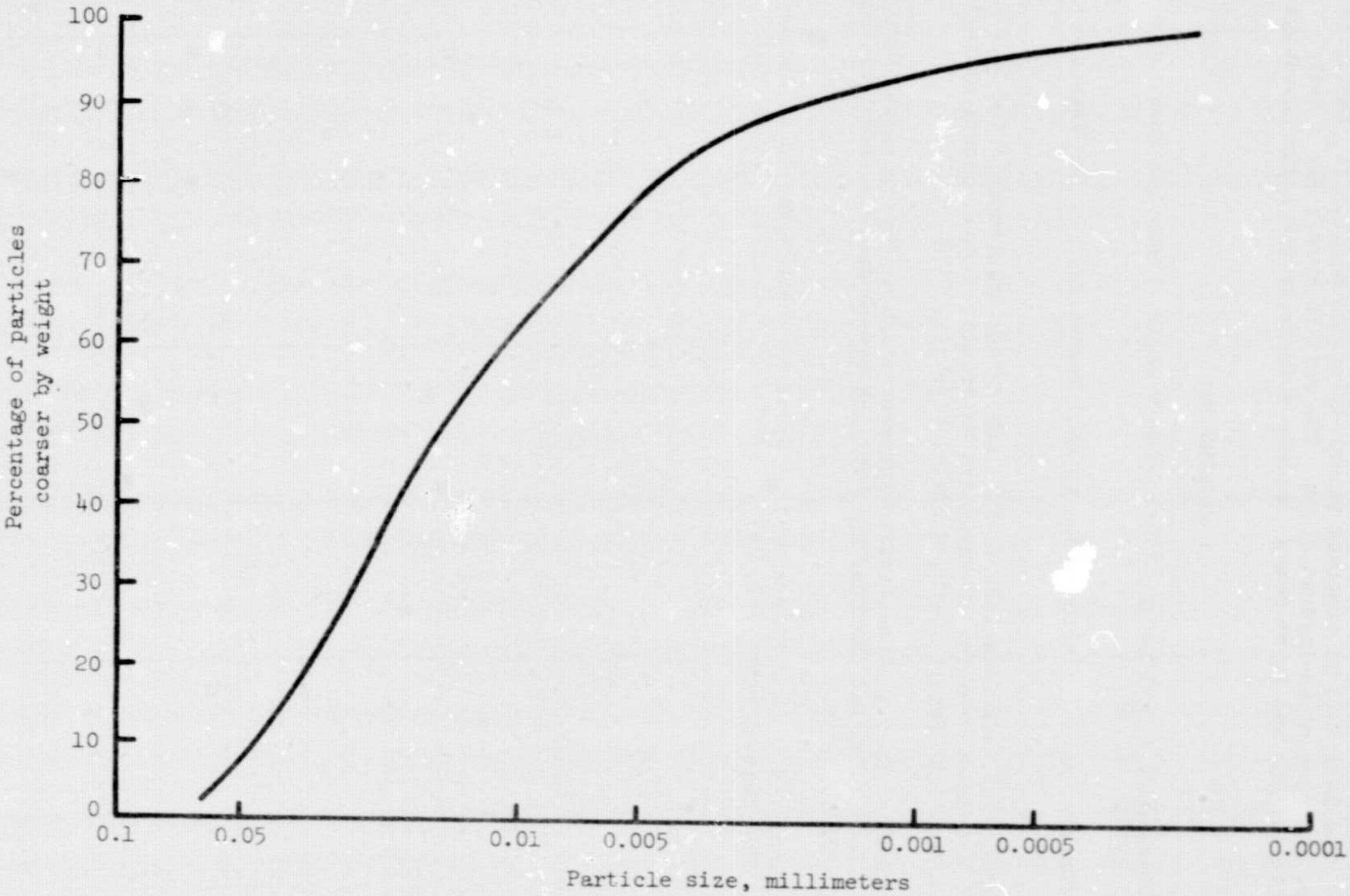

Figure 1.- Cumulative size distribution of Feldspar sample.

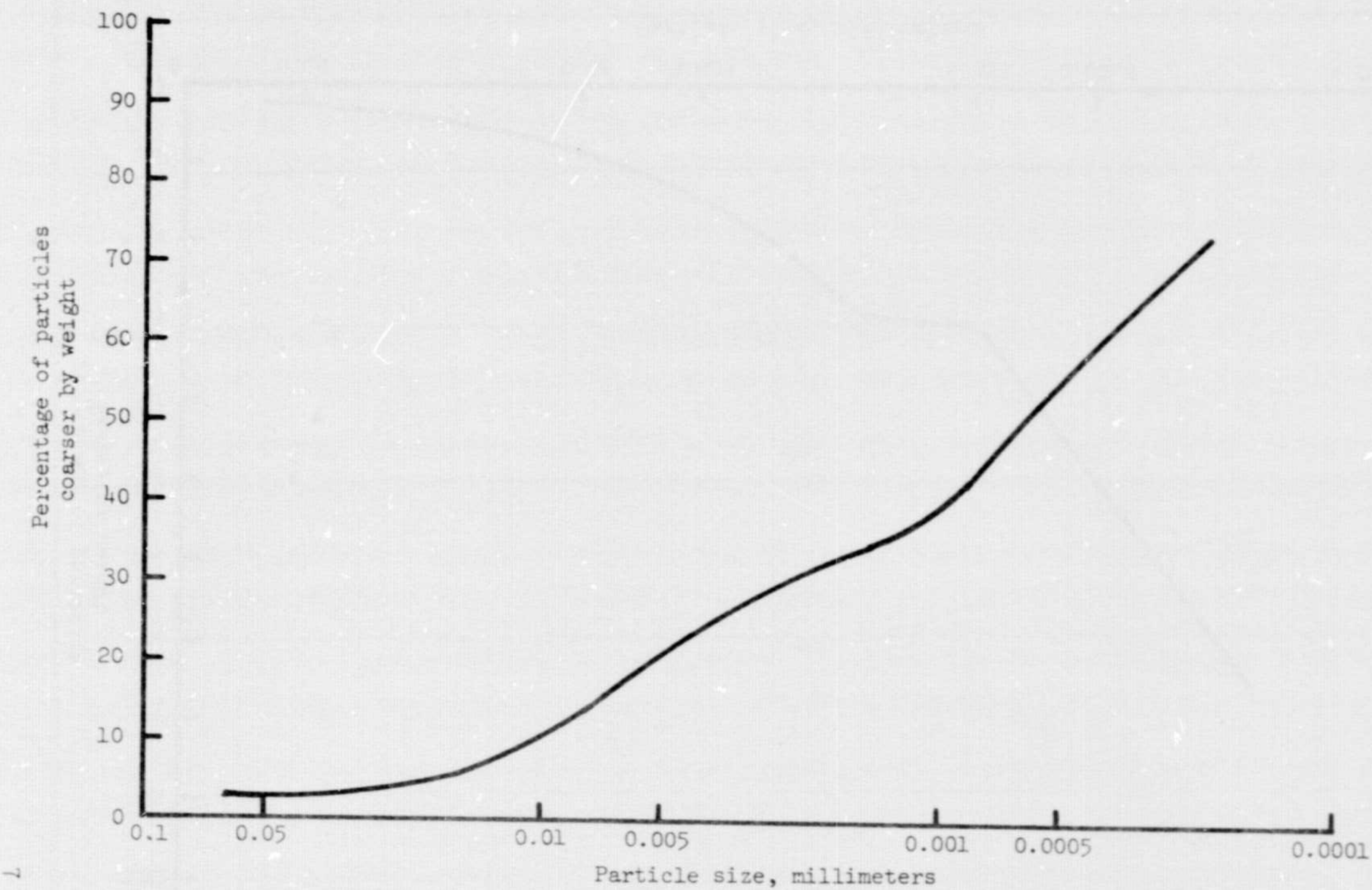

Figure 2.- Cumulative size distribution of Calvert sample.

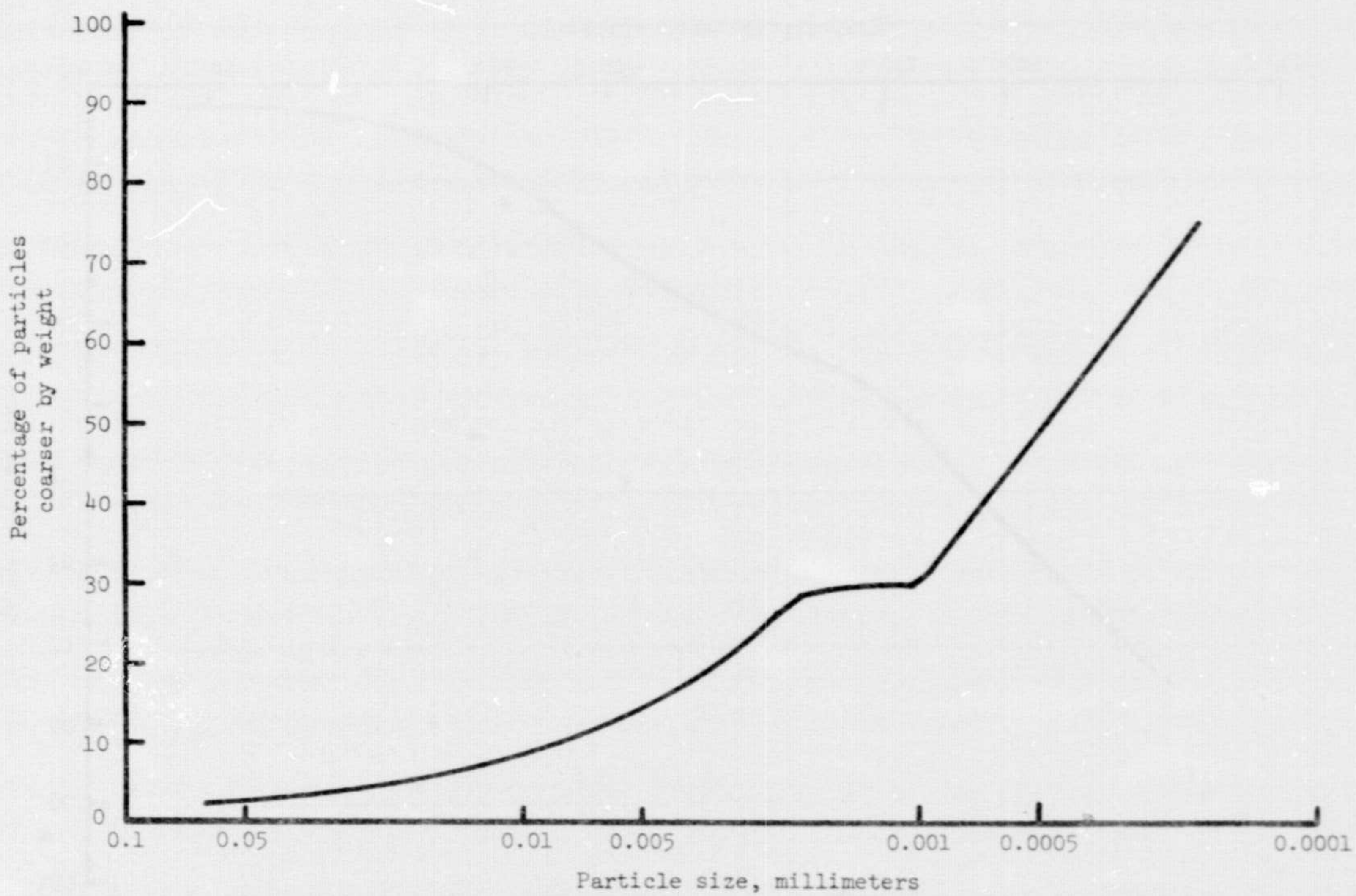

Figure 3.- Cumulative size distribution of Ball sample.

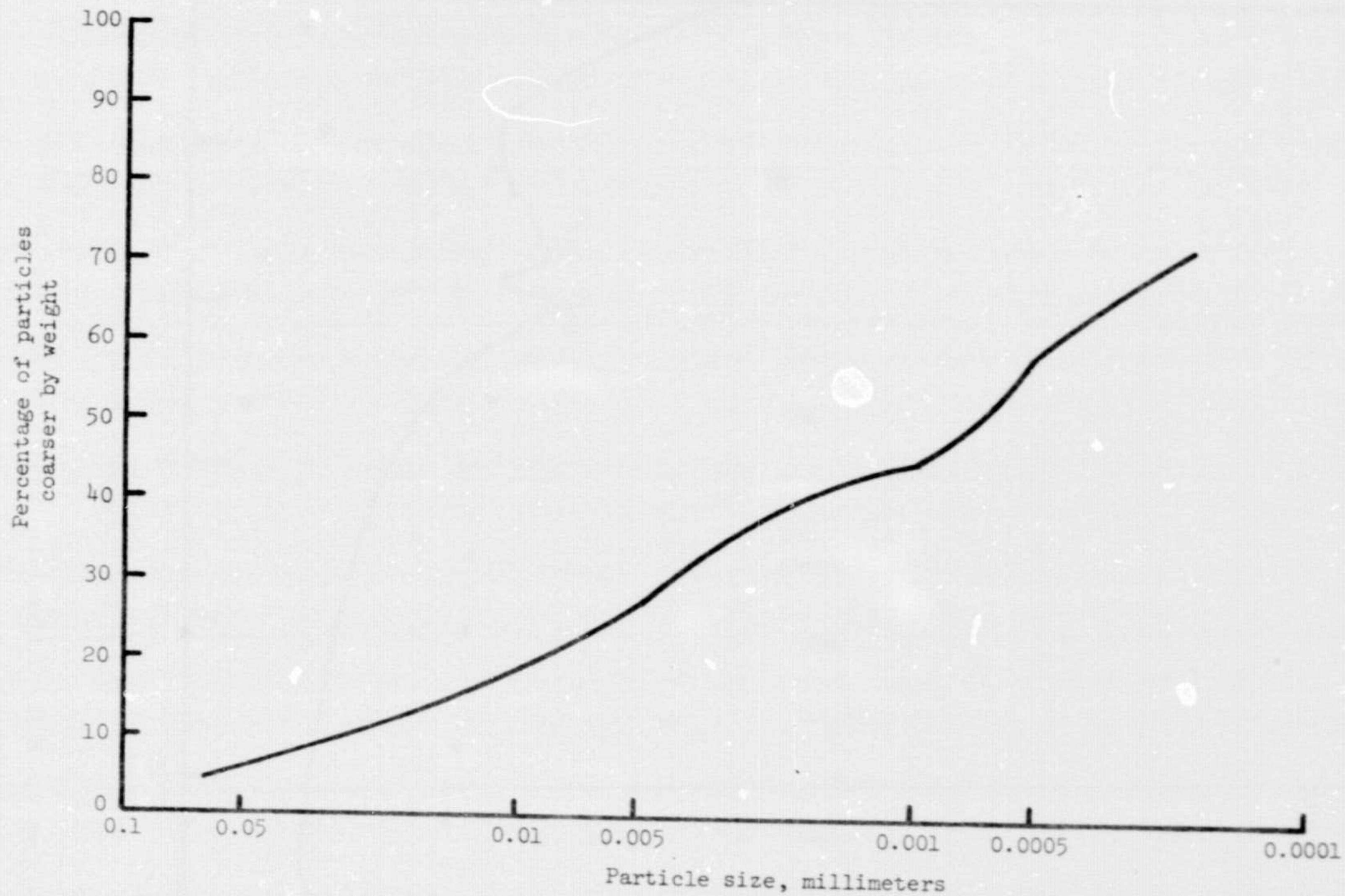

Figure 4.- Cumulative size distribution of Jordan sample.

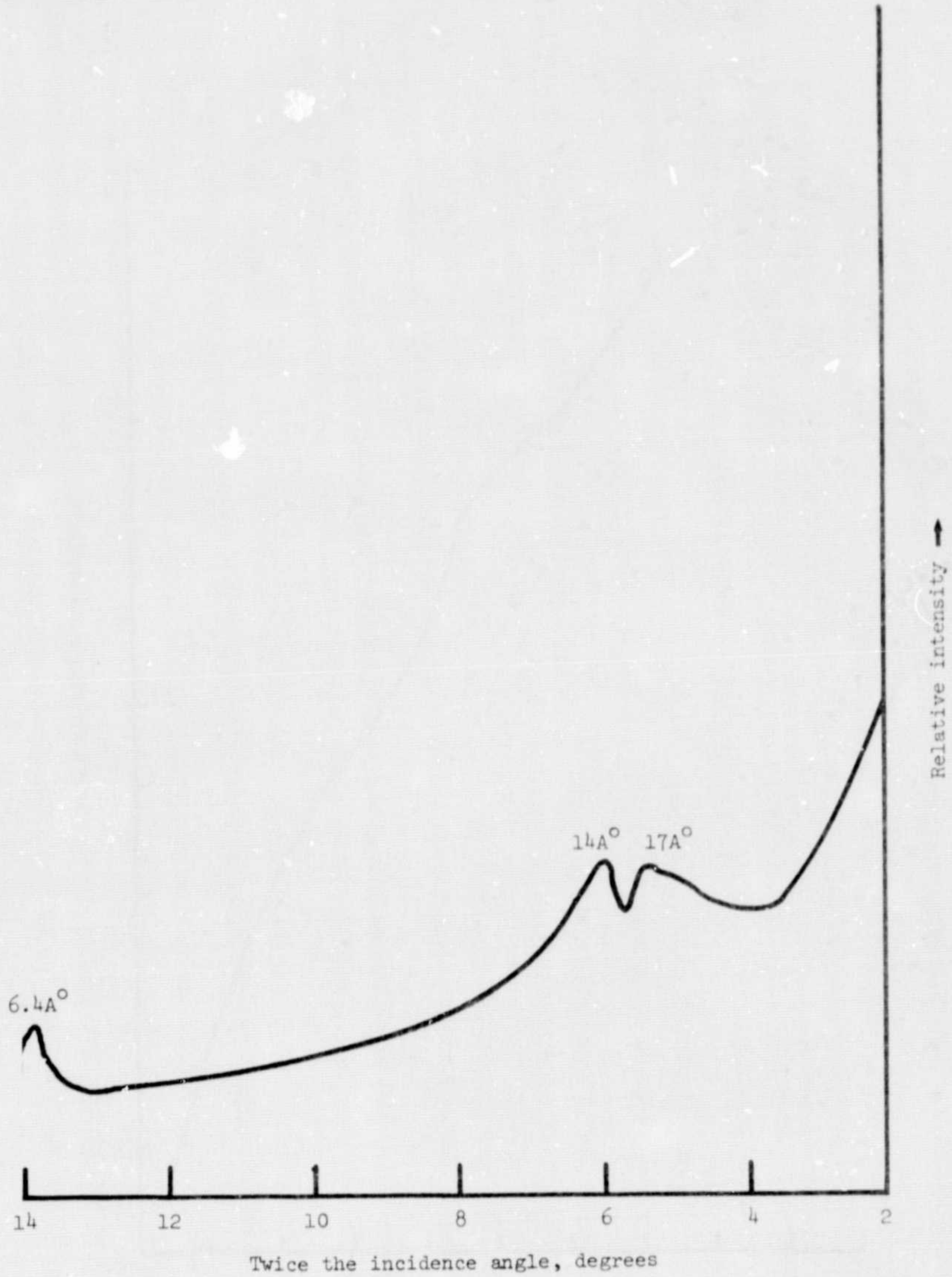

Figure 5.- X-ray diffraction pattern of untreated Feldspar Clay.

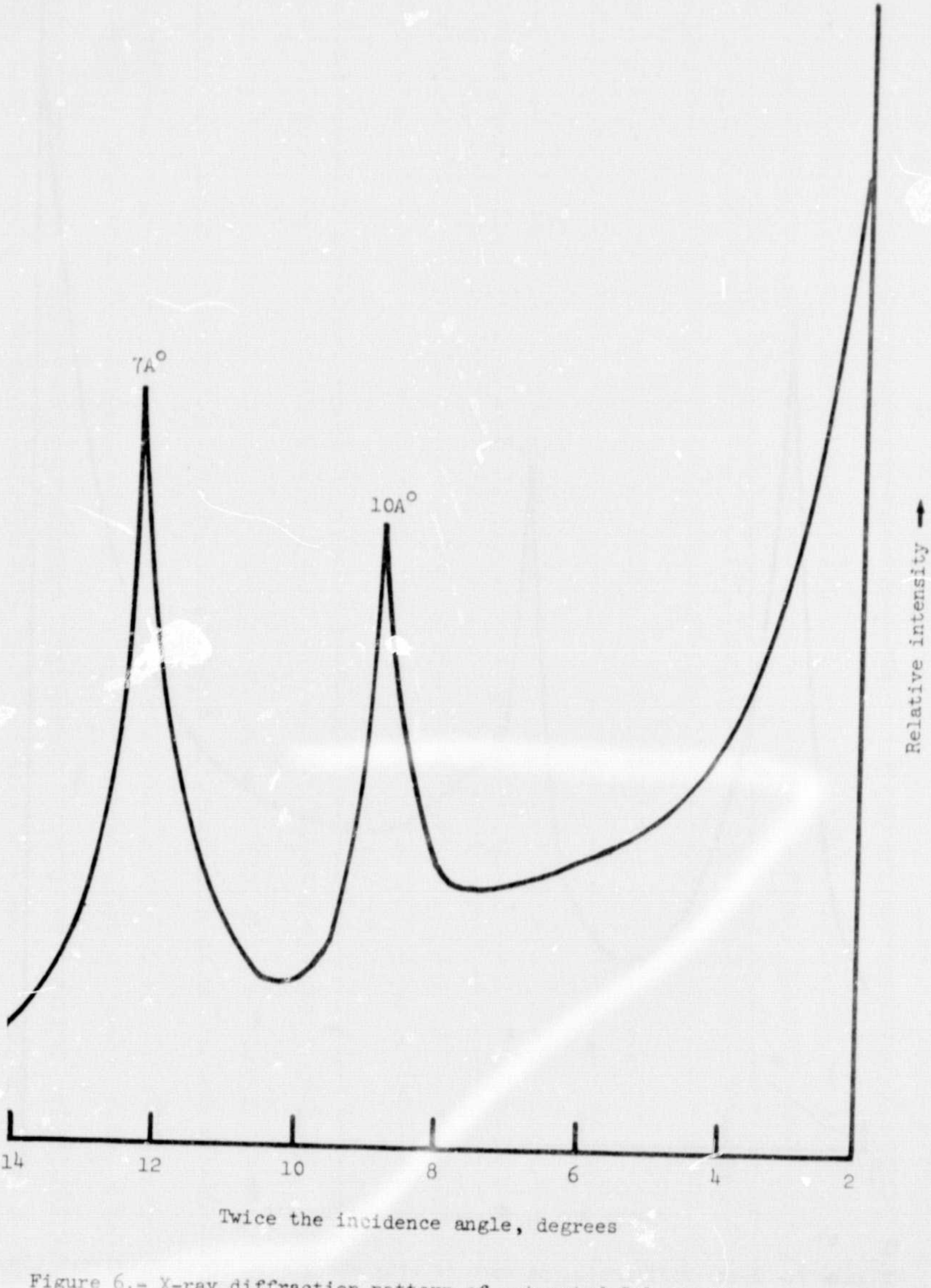

Figure 6.- X-ray diffraction pattern of untreated Calvert Clay.

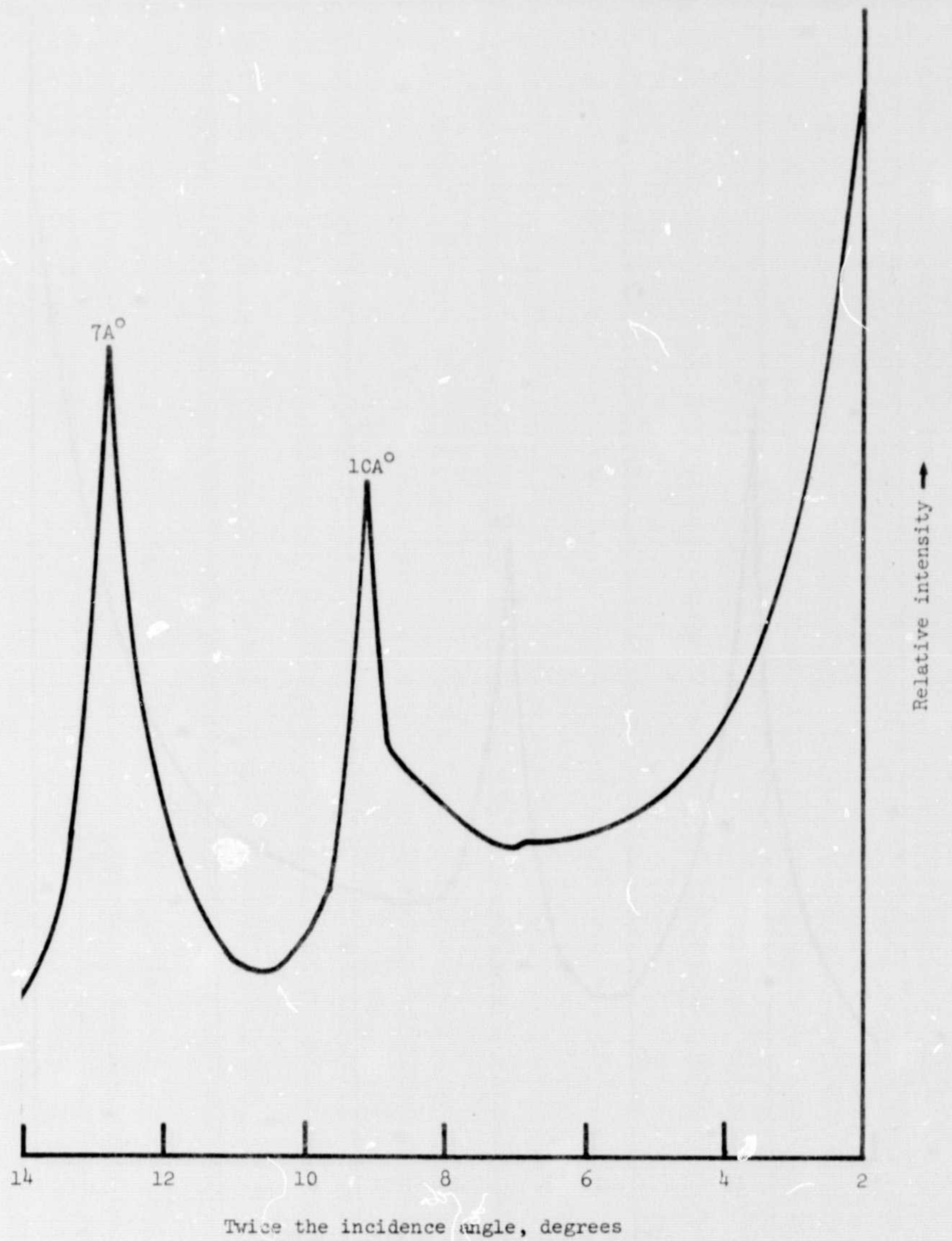

Figure 7.- X-ray diffraction pattern of ethylene glycol treated Calvert Clay.

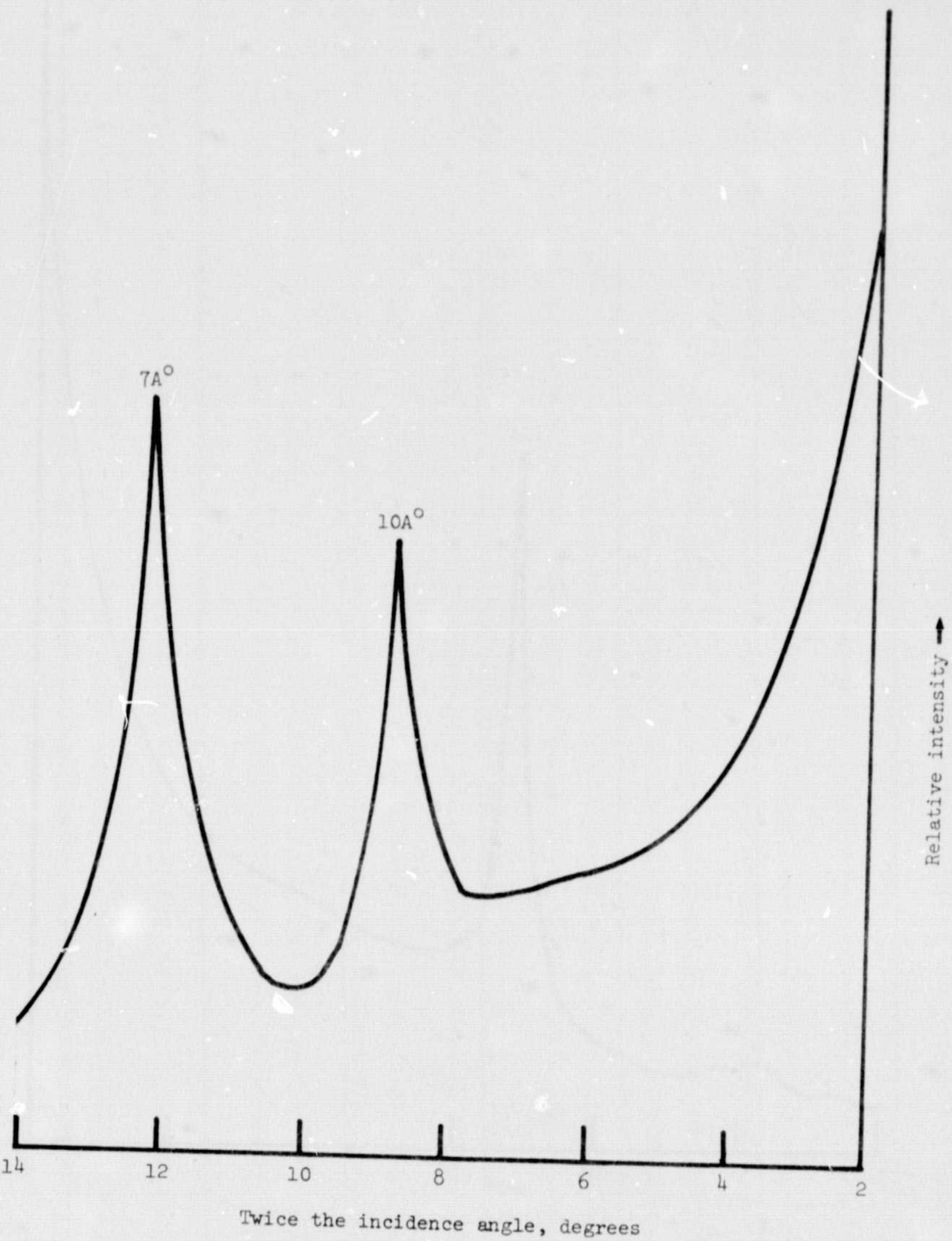

Figure 8.- X-ray diffraction pattern of 180°C treated Calvert Clay.

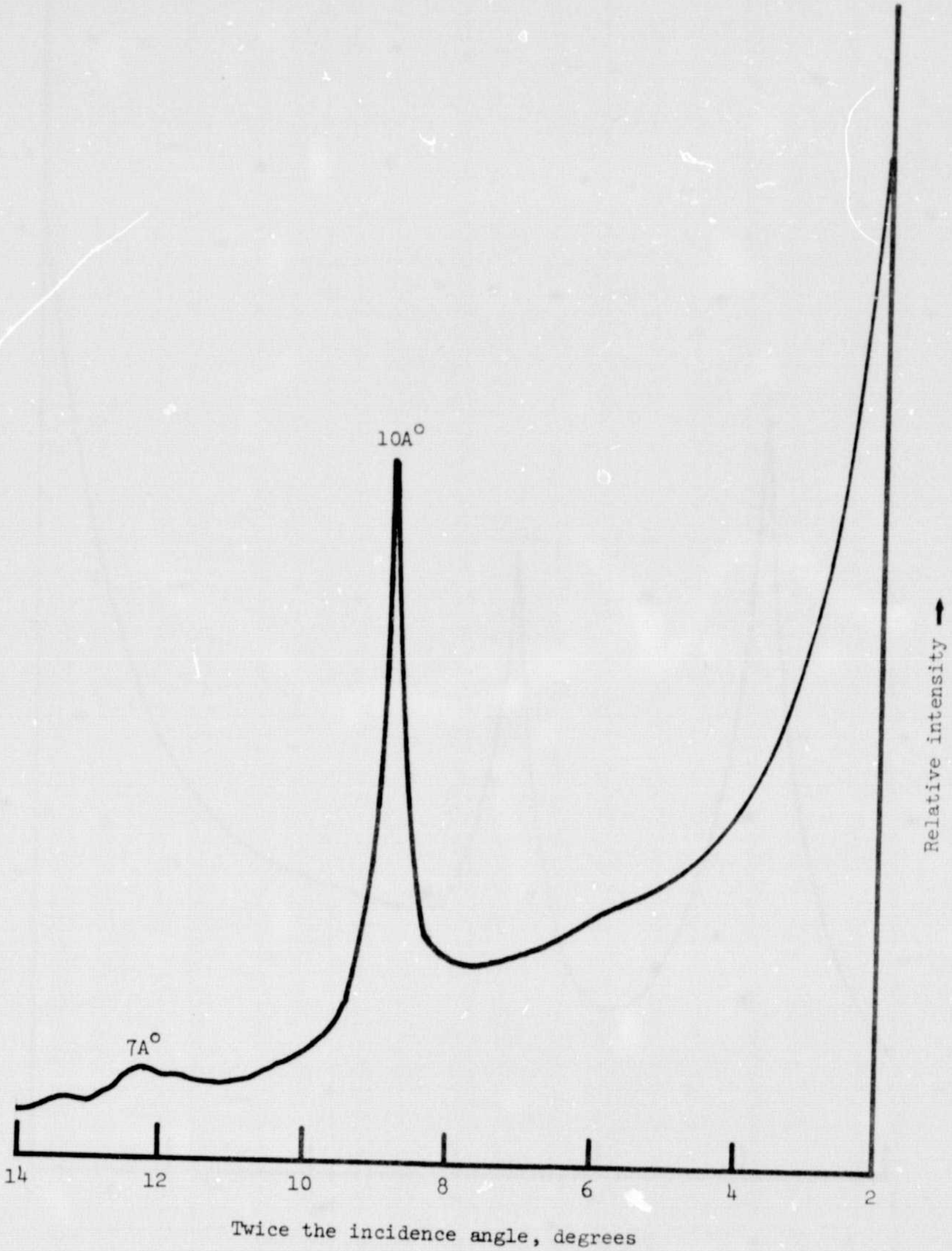

Figure 9.- X-ray diffraction pattern of 550°C treated Calvert Clay.

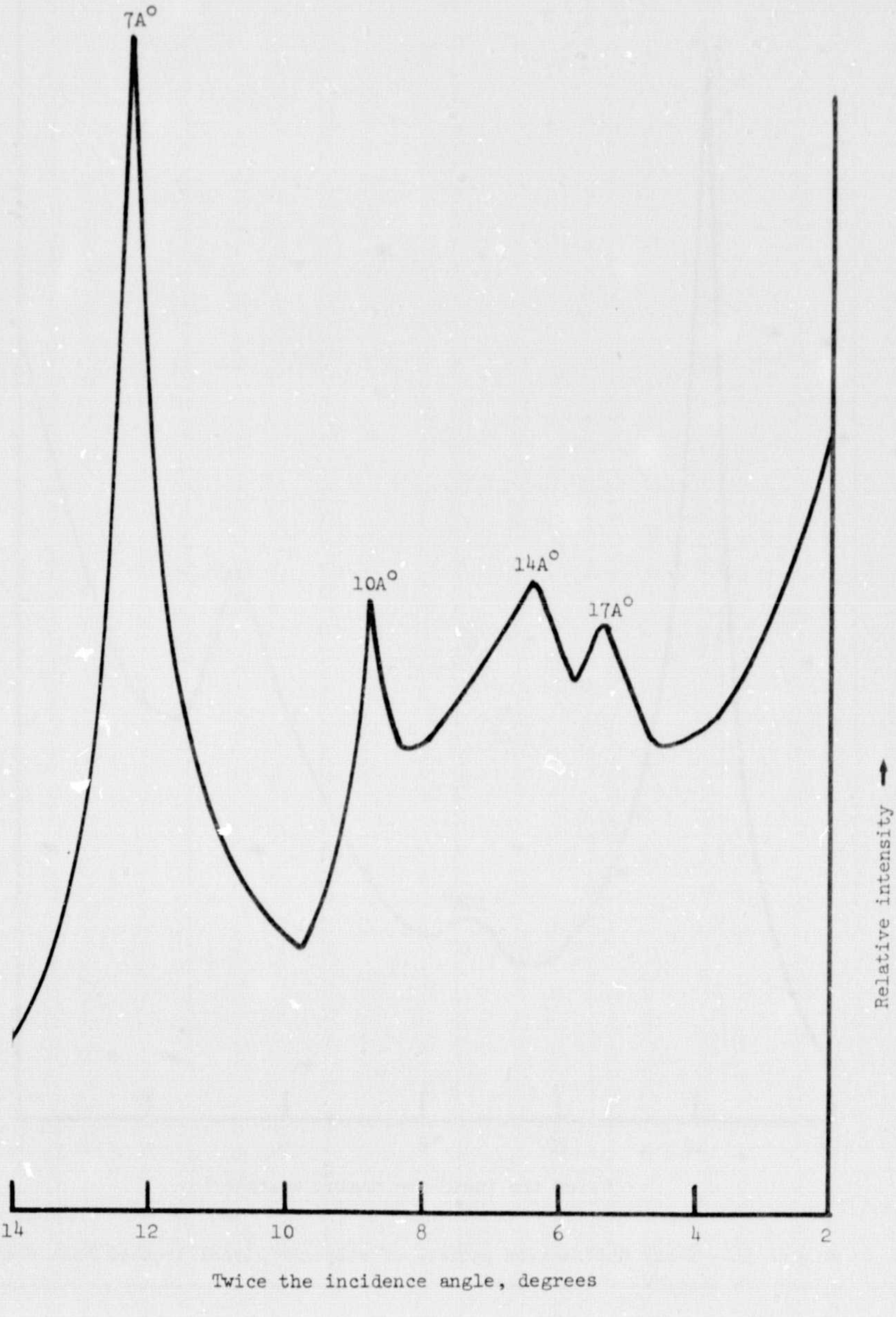

Figure 10.- X-ray diffraction pattern of untreated Ball Clay.

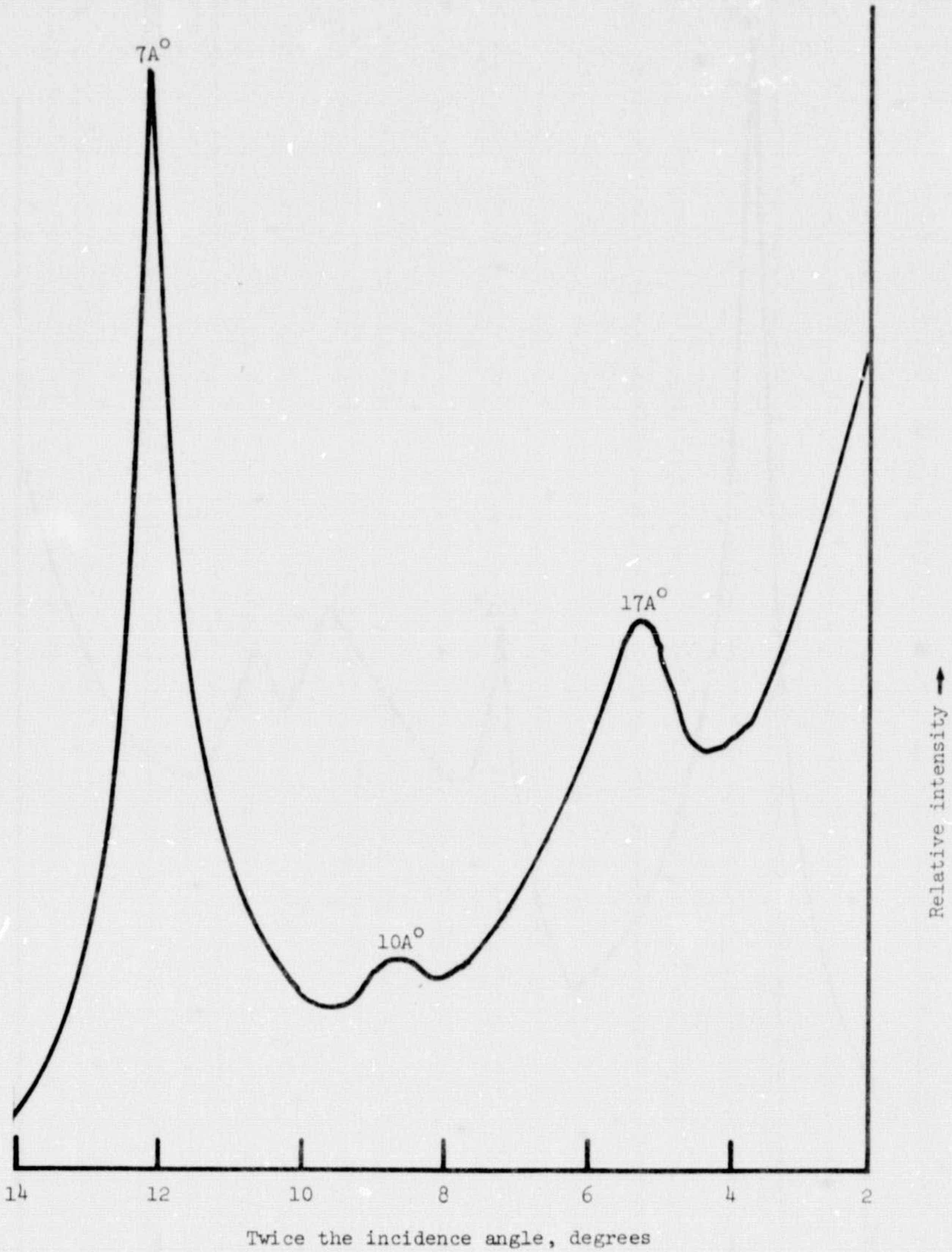

Figure 11.- X-ray diffraction pattern of ethylene glycol treated Ball Clay.

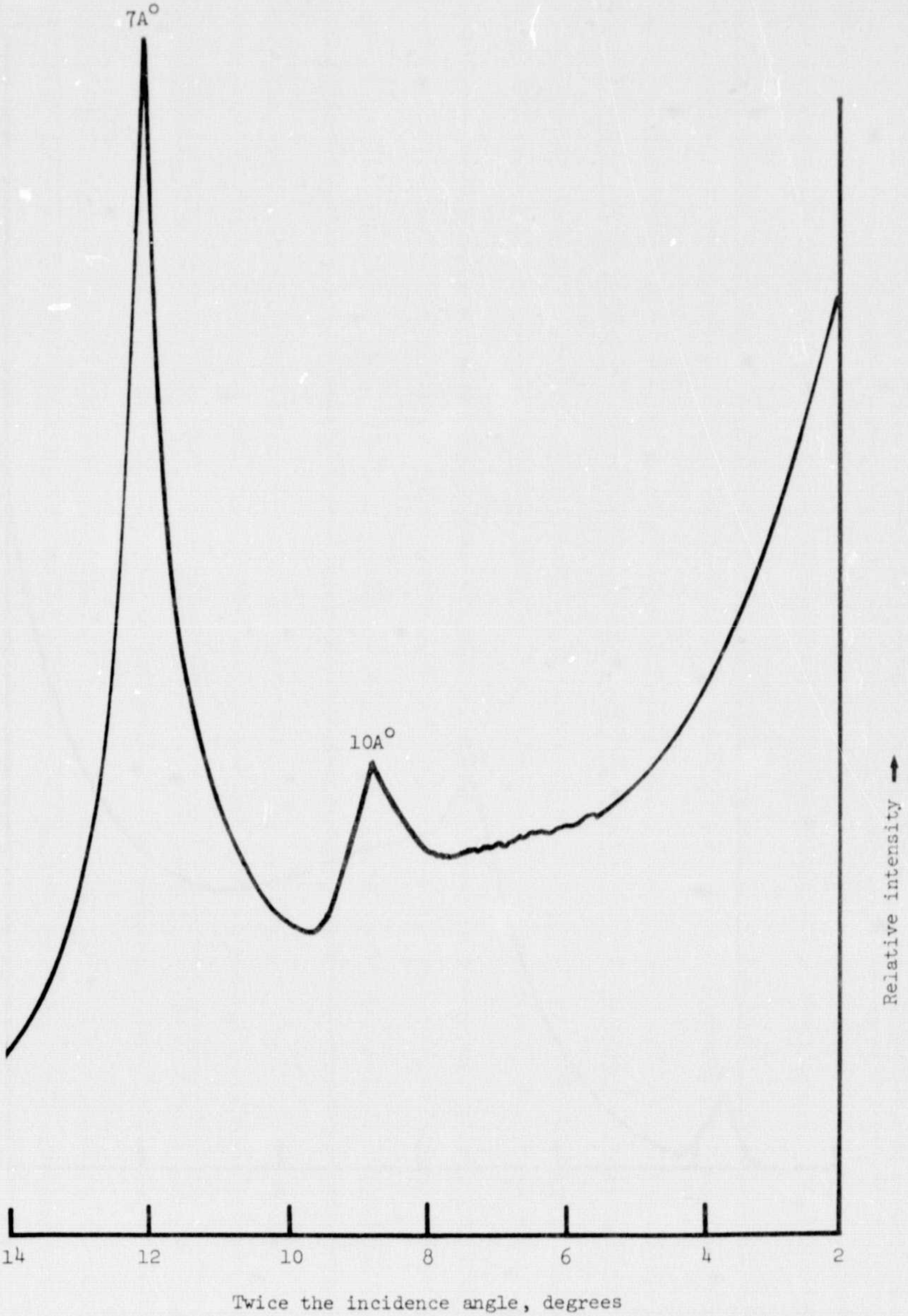

Figure 12.- X-ray diffraction pattern of 180°C treated Ball Clay.

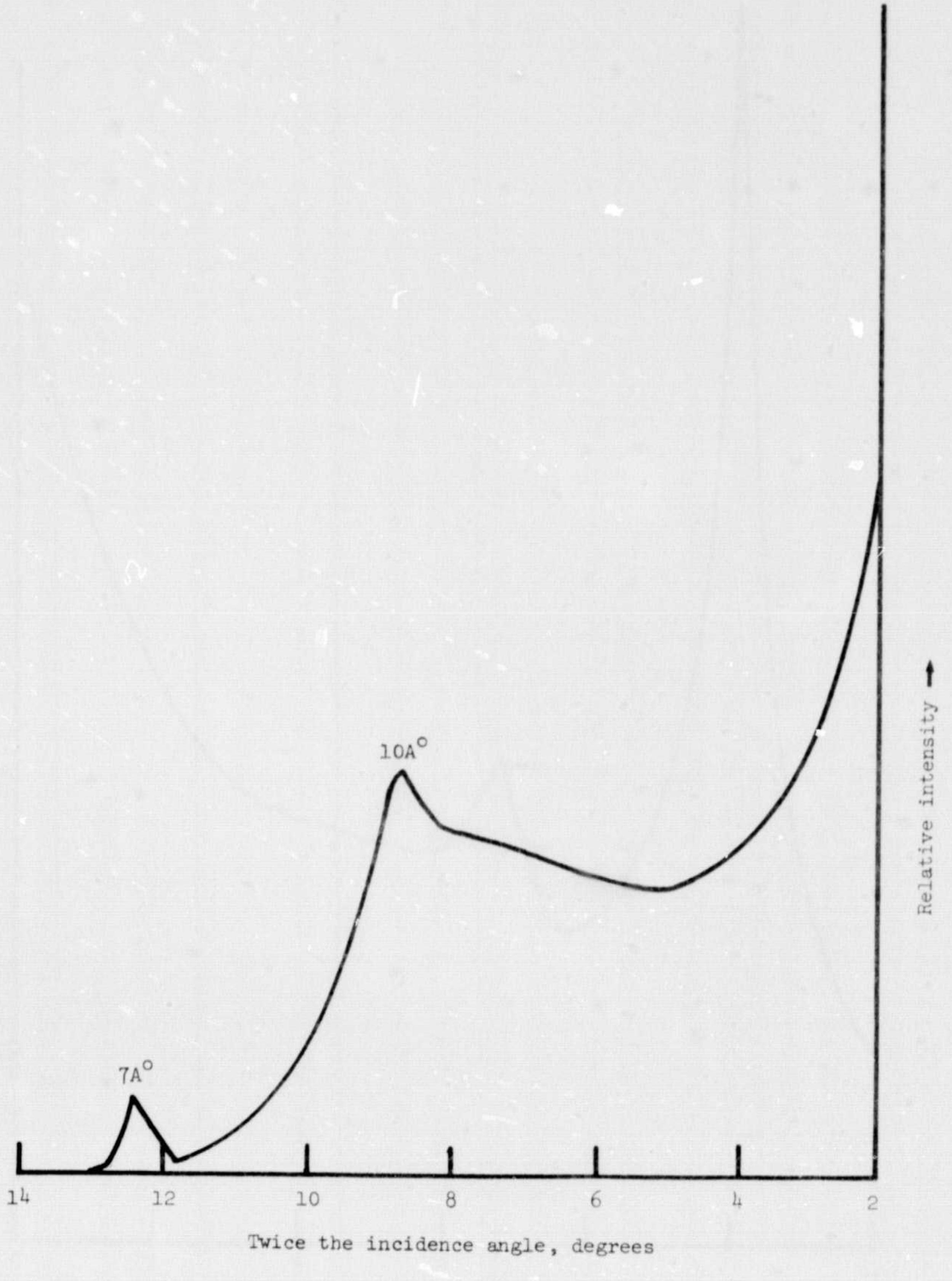

Figure 13.- X-ray diffraction pattern of 550°C treated Ball Clay.

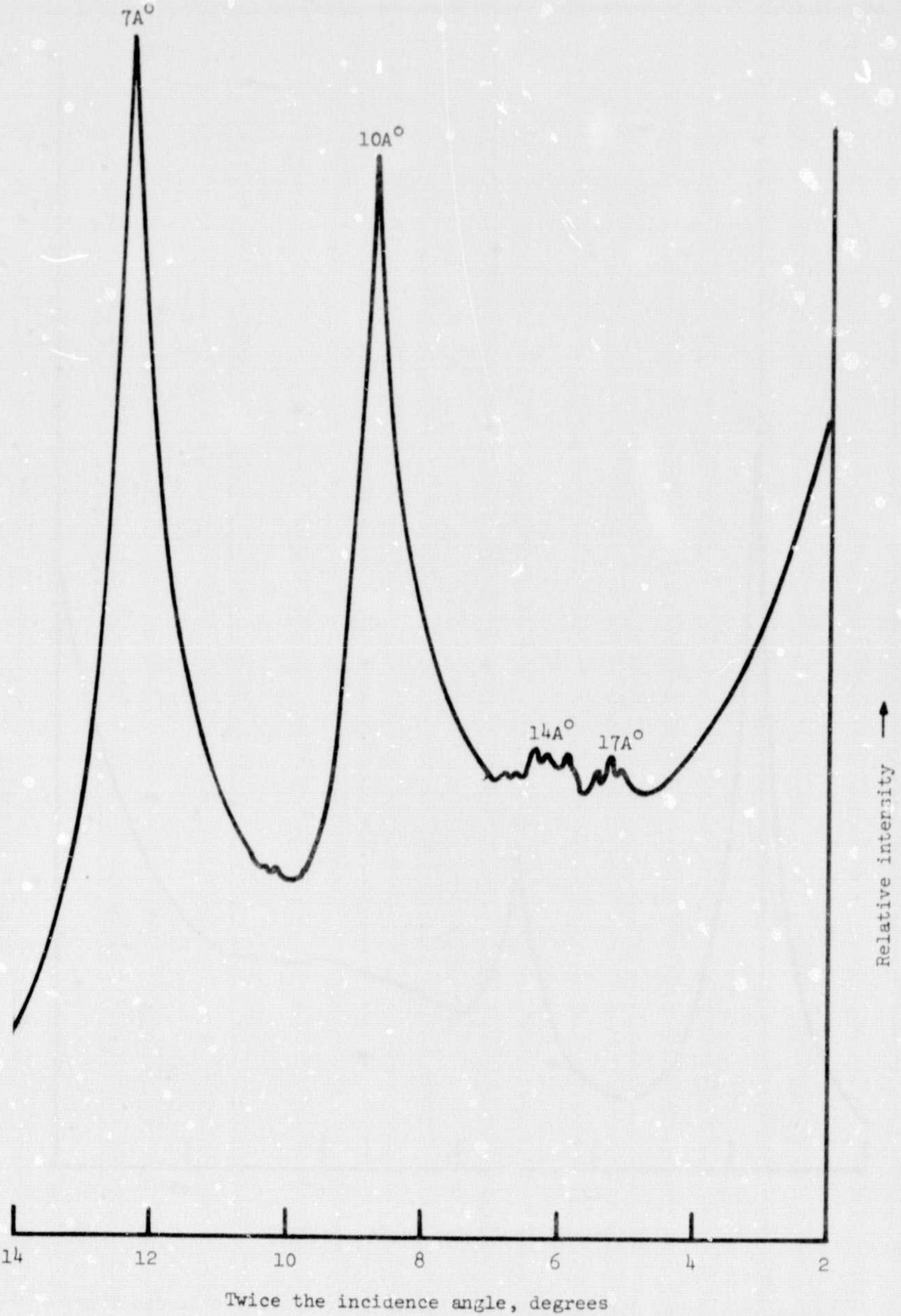

Figure 14.- X-ray diffraction pattern of untreated Jordan Clay.

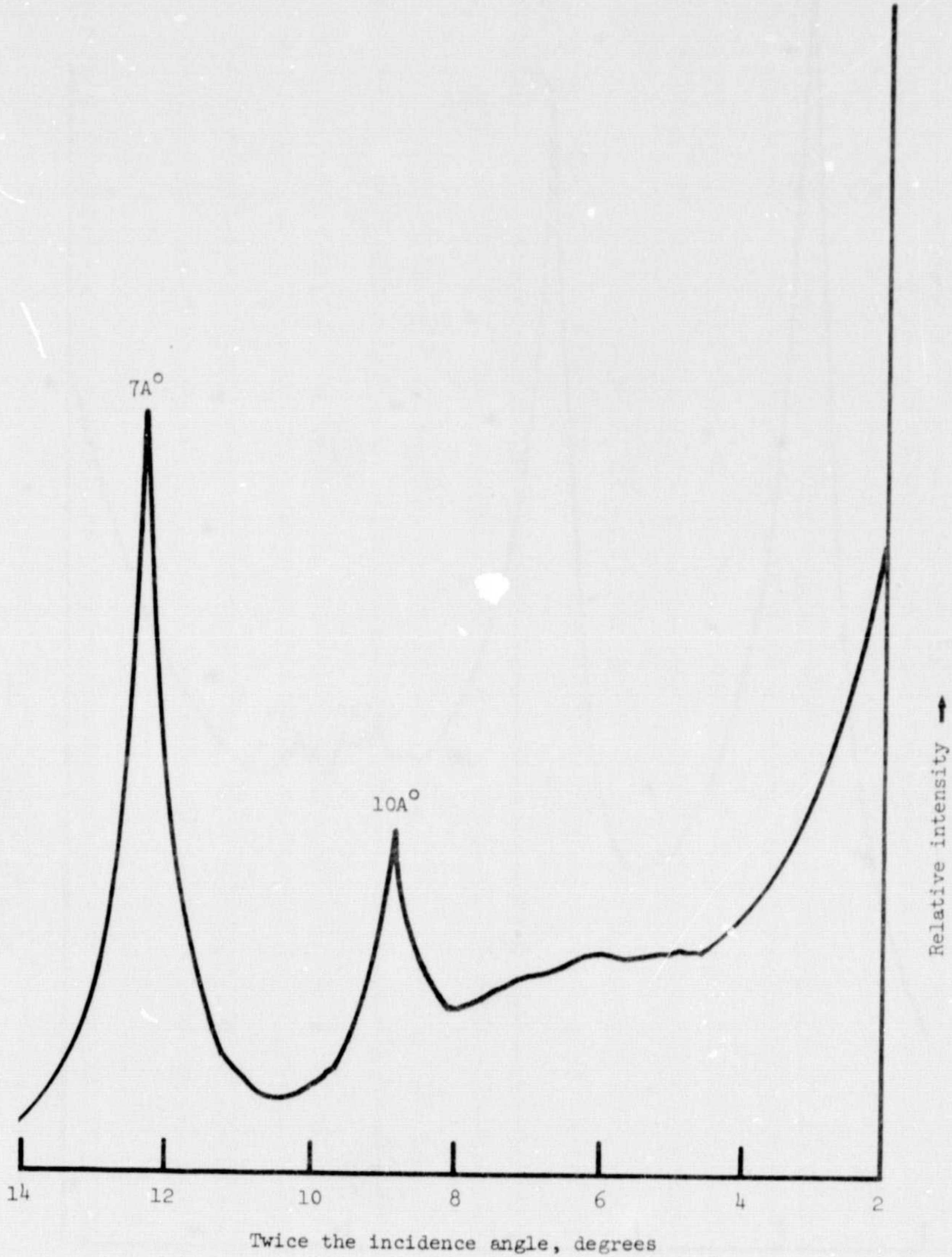

Figure 15.- X-ray diffraction of ethylene glycol treated Jordan Clay.

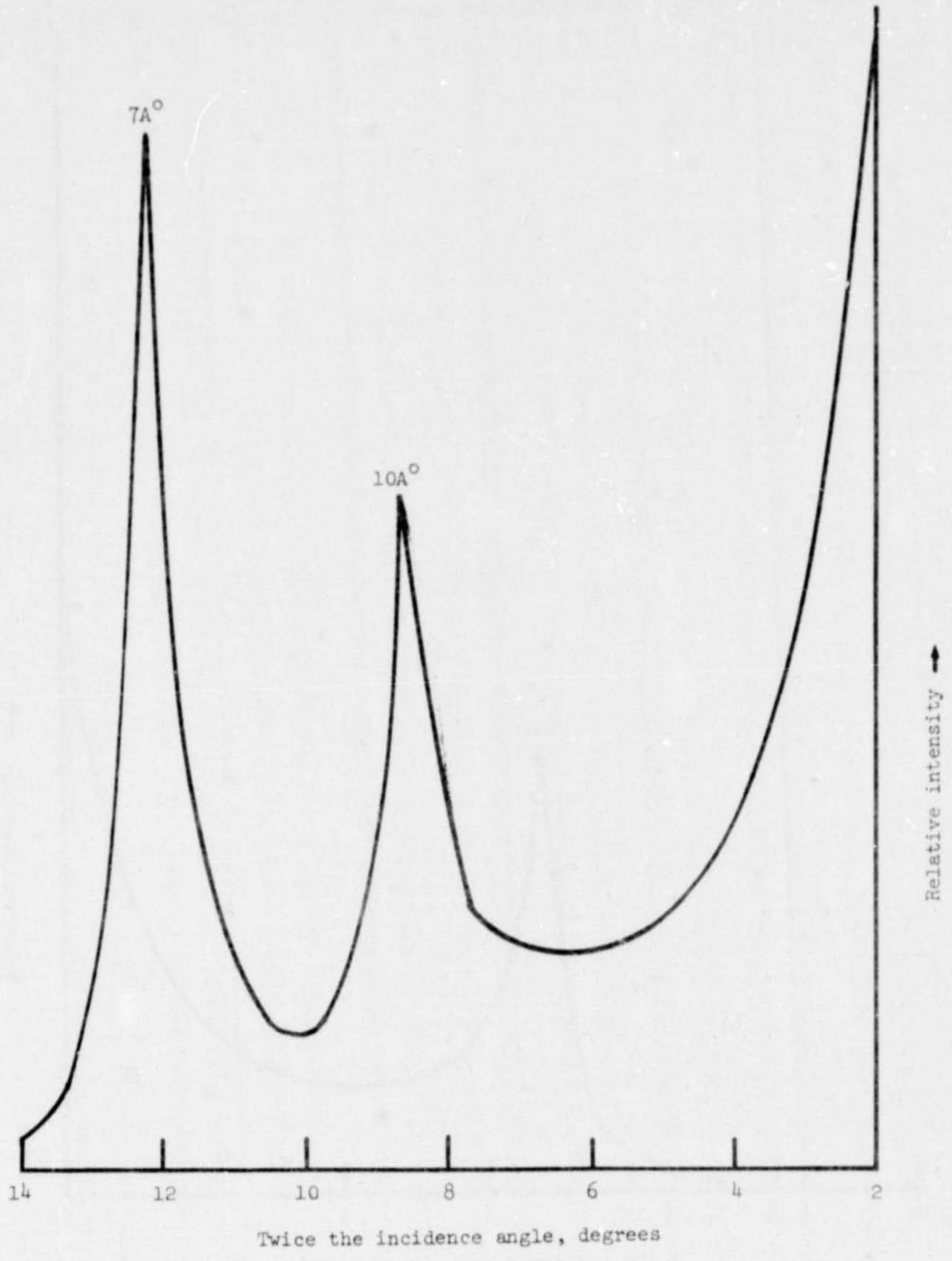

Figure 16.- X-ray diffraction pattern of 180°C treated Jordan Clay.

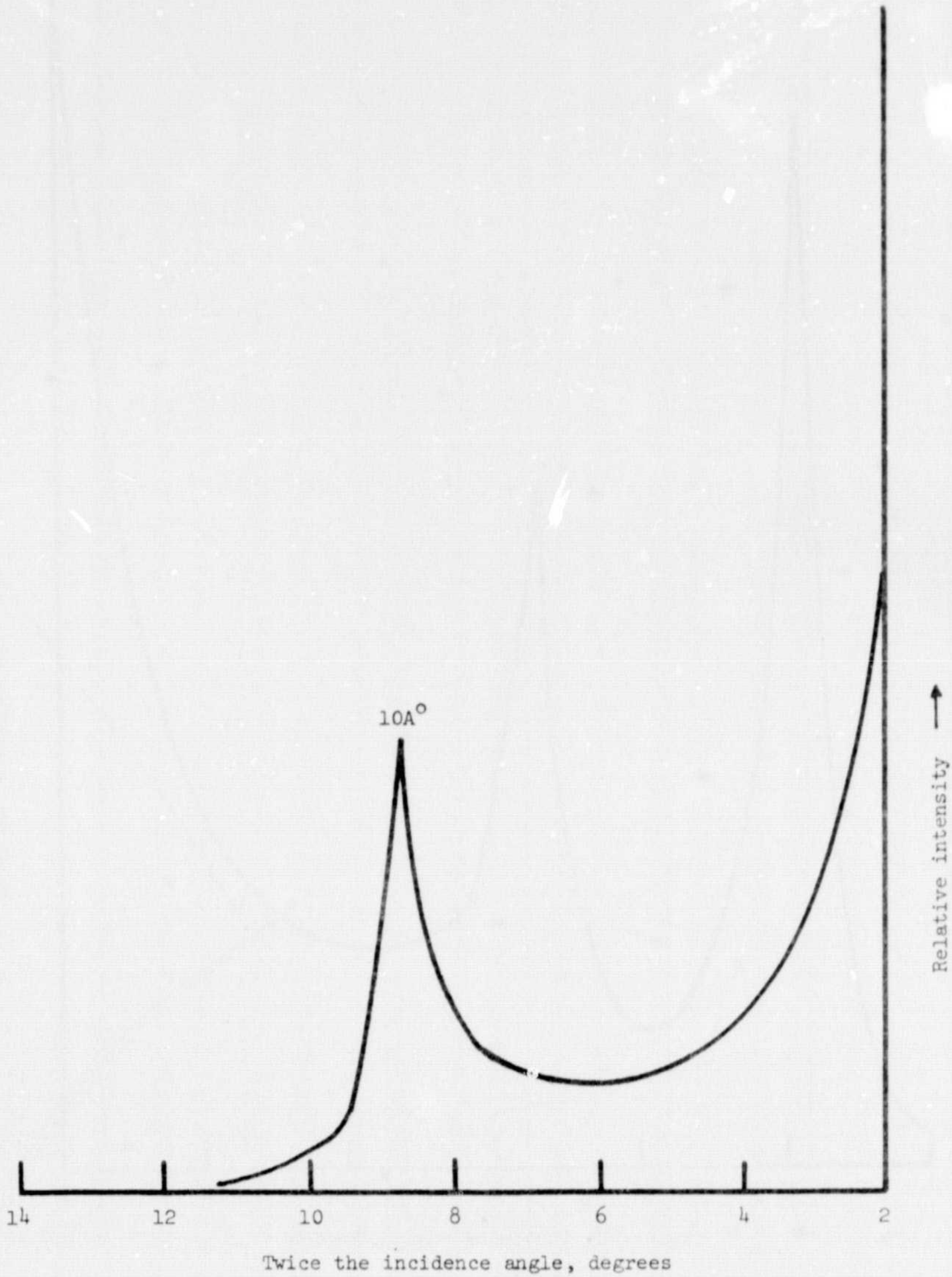

Figure 17.- X-ray diffraction pattern of 550°C treated Jordan Clay.