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Clay Sedimentation and Mineralogy in the Japan Trench

Saburo AOKI* and Norihiko KOHYAMA**

Abstract

Eight sediment traps (JT-04, 05, 06, and 07) were deployed at various depths of the Japan Trench during the period of November 1988 to March 1992. One hundred and four samples are analyzed for sedimentology and clay mineralogy by means of ATEM. The total number of lithogenic minerals amounts to 10,400. Five kinds of clay minerals and eight kinds of non-clay minerals were identified. Smectite is the most dominant constituent, having content ranging from 37% to 27%. Illite is the next most abundant clay mineral after smectite, having content of 35% to 17%. Quartz is the most dominant composition of the non-clay minerals, having content of 22% to 14%. Chemical analyses of the clay minerals show a variety of mineralogical characteristics. Smectite is grouped into a tri-octahedral Fe-Mg saponite and a di-octahedral Fe-Al beidellite as well as Al-Fe montmorillonite. Chlorite belongs to a tri-octahedral group to be subdivided into types Fe-Mg and Fe-Mg-Al. The lithogenic mineral composition and chemical characteristics of the clay minerals suggest that the lithogenic minerals in the present study are transported by the Kuroshio current as suspended material from the Japanese Islands and Philippine sea, and by wind as the loess from mainland China. The decreasing smectite abundance with increasing water depth seems to be related to the characteristics of smectite which tends to move horizontally longer in water.

The content of illite and quartz in the present samples does not necessarily show a good relationship, which is recognized as an indicator of the loess supply from mainland China as shown in a previous study otherwise.

Key words: Japan Trench, sedimentation, clay mineralogy, analytical transmission electron microscopy, sediment trap

INTRODUCTION

During the period of November 1988 to March 1992, eight sediment traps were deployed at various depths between 9,000 m and 1,000 m in the Japan Trench. The sediment samples collected have been studied by many researchers from various disciplines (Honjo, 1989; Oba, 1991; Matuoka, 1992; Tanimura, 1992; and so on). Aoki and Kohyama (1992) discussed the sources and sedimentary processes of the lithogenic mineral particles on the order of a few microns contained in trapped sample

* Natural Science Laboratory, Toyo University, 11–10, Oka 2, Asaka-shi, Saitama 351–8510, Japan
** National Institute of Industrial Health, 6–21–10 Nagao Tamaku, Kawasaki 214–8585, Japan
at depths of 4,000 m and 8,700 m for JT-02 and 03. Their results showed the lithogenic minerals are primarily transported from the Japanese Islands and the mainland China.

The supply from the Japanese Islands is transported by rivers and ocean currents such as the Kurohio, while the supply mainland China is air–borne dust the loess. The authors also discussed the velocity of the lithogenic particles sinking to the bottom of the Japan Trench. The purpose of this study is to discuss the newly obtained data at depths of 9,000; 8544; 5500; 5,000; 4235; 3,500; and 1,000 m in almost the same location of the Japan Trench, and discuss to reconsider the data reported previously.

**SAMPLES AND ANALYTICAL PROCEDURES**

The sediment trap was deployed in the Japan Trench at the northern extremity of the Izu–Ogasawara Trench located at the triple junction with the Sagami trough, as shown in Fig. 1. The sediment samples (JT-04, 05, 06, and 07) in this study were collected at eight different depths during the period of November 1988.

![Fig. 1 Location of sediment trap in this study.](image-url)
Clay Sedimentation and Mineralogy in the Japan Trench

Table 1 Data for sediment trap in this study.

<table>
<thead>
<tr>
<th></th>
<th>JT-04</th>
<th>JT-05</th>
<th>JT-06</th>
<th>JT-07</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trap Depth</td>
<td>4235 m</td>
<td>5035 m</td>
<td>5000 m</td>
<td>1000 m</td>
</tr>
<tr>
<td></td>
<td>8544 m</td>
<td>9000 m</td>
<td>3500 m</td>
<td>5500 m</td>
</tr>
<tr>
<td>Water Depth</td>
<td>6174 m</td>
<td>8972 m</td>
<td>9200 m</td>
<td>8942 m</td>
</tr>
<tr>
<td>Interval (day)</td>
<td>19 days</td>
<td>16 days</td>
<td>26 days</td>
<td>27 days</td>
</tr>
</tbody>
</table>

to March 1992 and amounted to 104 samples, consisting of 13 samples for each of the 8 traps. The depths, duration, and location of the sediment traps are listed in Table 1. Analysis of the minerals is based on the ATEM (analytical transmission electron microscope), Hitachi H8000 equipped with Kevex EDX H8110. Samples supplied for this study are too small quantity to be analyzed by X-ray diffraction analysis (XRD). One hundred mineral particles in each sample are identified by the ATEM and expressed as percentage. Accordingly, the total number of mineral particles identified is 10,400. The chemical composition of the clay minerals is expressed on a method reported by Kohyama (1983).

**RESULTS**

Thirteen kinds of minerals were identified in this study, 5 clay minerals and 8 non-clay minerals. Of the clay minerals, smectite shows an average content ranging from 40 to 27%, which is the highest abundance not only of the clay minerals but also of all the mineral compositions. Illite is the next most abundant mineral having an average content of 35% to 17%. Chlorite shows a constant average content ranging from 9 to 7%. Kaolinite has a minor amount ranging from 3 to 1%. Of the non-clay minerals, quartz has the highest average content ranging from 22 to 14%. Other silicic minerals such as plagioclase, Na-rich feldspar, and K-rich feldspar have an average content of 6 to 2%, 7 to 4%, and 3 to 1%, respectively. The mafic mineral having the highest content of 7 to 1%, is the Fe-Ti mineral. Other minerals are less than 1 % on the average.

Chemical analyses of the clay minerals are shown in Table 2, 3, and 4. Smectite is subdivided into three goups; a dioctahedral Fe-Al beidellite which is the most common in most samples, a tri-octahedral Fe-Mg saponite which is the next most abundant species, and a di-octahedral Al-Fe montmorillonite which is not common
Table 2 Chemical composition and structural formulae of smectite.

<table>
<thead>
<tr>
<th></th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
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<tbody>
<tr>
<td>SiO₂</td>
<td>58.53</td>
<td>60.64</td>
<td>35.56</td>
<td>55.09</td>
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<tr>
<td>Al₂O₃</td>
<td>18.47</td>
<td>15.33</td>
<td>23.90</td>
<td>27.12</td>
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<tr>
<td>MgO</td>
<td>4.54</td>
<td>3.24</td>
<td>10.97</td>
<td>1.37</td>
</tr>
<tr>
<td>Fe₂O₃(FeO)</td>
<td>13.46</td>
<td>10.47</td>
<td>(22.05)</td>
<td>12.50</td>
</tr>
<tr>
<td>CaO</td>
<td>1.91</td>
<td>1.93</td>
<td>2.87</td>
<td>1.03</td>
</tr>
<tr>
<td>MnO</td>
<td>0.54</td>
<td>2.69</td>
<td>1.56</td>
<td>0.78</td>
</tr>
<tr>
<td>TiO₂</td>
<td>1.03</td>
<td>2.84</td>
<td>2.38</td>
<td>0.56</td>
</tr>
<tr>
<td>Na₂O</td>
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<td>—</td>
<td>—</td>
<td>0.41</td>
</tr>
<tr>
<td>K₂O</td>
<td>1.11</td>
<td>2.86</td>
<td>0.71</td>
<td>1.14</td>
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</tbody>
</table>

Total (%) 100.00 100.00 100.00 100.00

<table>
<thead>
<tr>
<th></th>
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<th>B</th>
<th>C</th>
<th>D</th>
</tr>
</thead>
<tbody>
<tr>
<td>Si</td>
<td>3.64</td>
<td>3.80</td>
<td>2.50</td>
<td>3.41</td>
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<tr>
<td>Al</td>
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<td>0.20</td>
<td>1.50</td>
<td>0.59</td>
</tr>
<tr>
<td>Tetra.</td>
<td>4.00</td>
<td>4.00</td>
<td>4.00</td>
<td>4.00</td>
</tr>
<tr>
<td>Al</td>
<td>0.99</td>
<td>0.93</td>
<td>0.48</td>
<td>1.39</td>
</tr>
<tr>
<td>Mg</td>
<td>0.42</td>
<td>0.30</td>
<td>1.15</td>
<td>0.13</td>
</tr>
<tr>
<td>Fe³⁺(Fe²⁺)</td>
<td>0.63</td>
<td>0.49</td>
<td>(1.30)</td>
<td>0.58</td>
</tr>
<tr>
<td>Mn</td>
<td>0.03</td>
<td>0.14</td>
<td>0.09</td>
<td>0.04</td>
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<tr>
<td>Ti</td>
<td>0.05</td>
<td>0.13</td>
<td>0.13</td>
<td>0.03</td>
</tr>
<tr>
<td>Octa.</td>
<td>2.12</td>
<td>1.99</td>
<td>3.15</td>
<td>2.17</td>
</tr>
<tr>
<td>Ca</td>
<td>0.13</td>
<td>0.13</td>
<td>0.22</td>
<td>0.07</td>
</tr>
<tr>
<td>Na</td>
<td>0.05</td>
<td>0.13</td>
<td>—</td>
<td>0.05</td>
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<tr>
<td>K</td>
<td>0.09</td>
<td>0.23</td>
<td>0.06</td>
<td>0.09</td>
</tr>
<tr>
<td>Inter.</td>
<td>0.27</td>
<td>0.36</td>
<td>0.28</td>
<td>0.21</td>
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</tbody>
</table>

Structural formulae are calculated on the basis of O₁₀(OH)₈.
A, B, and D show Al-Fe beidellite and C is Fe-Mg saponite.
These symbols correspond to those Fig. 2
Tetra.: tetrahedral layer, Octa.: octahedral layer, Inter.: interlayer.

in the samples. Chlorite in this study belongs to a tri-octahedral type which is divided into two groups, Fe-Mg type and Fe-Mg-Al type, by the content of each cation in the octahedral layer. Illite is a di-octahedral type which is rich in potassium.

DISCUSSION

As to the study of clay mineralogy and factors affecting clay mineral composition in sediment trap samples collected in different seas, Honjo et al. (1982) pointed out the decreasing and increasing abundances of smectite, chlorite, and illite at different depths and different oceans. Ramaswamy et al. (1991) reported that illite and quartz are the most dominant minerals in samples trapped in the Arabian sea, and these lithogenic minerals are largely influenced by the biological production. Berner and Wefer (1994) described the close relationship between the kaolinite/illite ratio and current systems from a study of the sediment-trapped samples collected
### Table 3  Chemical composition and structural formulae of chlorite.

<table>
<thead>
<tr>
<th></th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
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</thead>
<tbody>
<tr>
<td>SiO₂</td>
<td>26.92</td>
<td>24.42</td>
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<tr>
<td>Al₂O₃</td>
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<td>24.73</td>
<td>22.11</td>
<td>26.93</td>
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<tr>
<td>MgO</td>
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<td>12.83</td>
<td>5.36</td>
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<tr>
<td>FeO</td>
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<td>27.40</td>
<td>27.56</td>
</tr>
<tr>
<td>CaO</td>
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<td>1.29</td>
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<td>0.89</td>
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<tr>
<td>MnO</td>
<td>1.32</td>
<td>1.36</td>
<td>0.46</td>
<td>0.72</td>
</tr>
<tr>
<td>TiO₂</td>
<td>1.48</td>
<td>1.04</td>
<td>0.53</td>
<td>1.42</td>
</tr>
<tr>
<td>Na₂O</td>
<td>—</td>
<td>0.41</td>
<td>—</td>
<td>0.70</td>
</tr>
<tr>
<td>K₂O</td>
<td>1.16</td>
<td>0.93</td>
<td>2.53</td>
<td>0.46</td>
</tr>
<tr>
<td>Total (%)</td>
<td>100.00</td>
<td>100.00</td>
<td>100.00</td>
<td>100.00</td>
</tr>
</tbody>
</table>

Structural formulae are calculated on the basis of O₁₀(OH)₂. A, B, and D show Fe-Mg beidellite and D is Al-Fe chlorite. These symbols correspond to those Fig. 3. Tetra.: tetrahedral layer, Octa.: octahedral layer, Inter.: interlayer.

### Table 4  Chemical composition and structural formulae of illite.

<table>
<thead>
<tr>
<th></th>
<th>A</th>
<th>B</th>
</tr>
</thead>
<tbody>
<tr>
<td>SiO₂</td>
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<td>54.41</td>
</tr>
<tr>
<td>Al₂O₃</td>
<td>28.18</td>
<td>27.76</td>
</tr>
<tr>
<td>MgO</td>
<td>1.70</td>
<td>3.10</td>
</tr>
<tr>
<td>Fe₂O₃</td>
<td>4.56</td>
<td>4.63</td>
</tr>
<tr>
<td>CaO</td>
<td>3.16</td>
<td>0.37</td>
</tr>
<tr>
<td>MnO</td>
<td>1.20</td>
<td>0.28</td>
</tr>
<tr>
<td>TiO₂</td>
<td>1.76</td>
<td>0.42</td>
</tr>
<tr>
<td>Na₂O</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>K₂O</td>
<td>9.97</td>
<td>9.03</td>
</tr>
<tr>
<td>Total (%)</td>
<td>100.00</td>
<td>100.00</td>
</tr>
</tbody>
</table>

Structural formulae are calculated on the basis of O₁₀(OH)₂. A and B show illite rich in potassium. These symbols correspond to those Fig. 4. Tetra.: tetrahedral layer, Octa.: octahedral layer, Inter.: interlayer.
from the Farm strait and the Norwegian sea.

As the authors (1992) pointed out, there are two mechanisms governing the transport of lithogenic mineral particles to the area studied. The first transport mechanism is rivers and the Kuroshio current, which supply suspended material from the Japanese Islands and the Izu-volcanic islands close to the sediment trap site. Turbidity currents may also play a significant role in the transport of lithogenic matter because submarine earthquake frequently occur in the study area and its environs. The second major mechanism is air-borne dust, like the loess from mainland China. The mineral species and quantity of minerals seem to be closely related to the source area and the mechanisms of transport of the lithogenic minerals contained in the samples trapped. In addition, it may be possible to determine the velocity of sinking of these mineral particles to the bottom of the trench if the origin of minerals contained in the samples is clarified.

The Japanese Islands and Izu volcanic islands close to the sediment trap site are the most important sources of clay minerals such as illite, chlorite, smectite, and a small amount of kaolinite. This is confirmed by a study of the clay minerals in sediments from Suruga Bay, Sagami Bay, Tokyo Bay, and off Boso Peninsula along the Pacific side of the Japanese Islands (Aoki and Kohyama, 1992). This is also inferred from clay minerals in sediments from the Izu-Ogasawara Trench and the Japan Trench, as reported by Oinuma and Kobayashi (1966) and Aoki and Oinuma (1985). However, there is a difference in clay mineral composition between the sediment traps and bottom sediment samples; the former are rich in smectite but the latter are rich in chlorite and illite. As pointed out in the previous paper by Aoki and Kohyama (1992), this difference is due to the processing of the samples by means of XRD and ATEM.

Chemical analyses of clay minerals suggest that clay minerals in this study have various source areas. Smectite in this study is subdivided into a tri-octahedral saponite and a di-octahedral beidellite, and montmorillonite. On the one hand, smectite in sediments on the continental slope off Boso Peninsula close to the trap site is restricted to a di-octahedral Fe-Al beidellite (Aoki, 1994). On the other hand, smectite in sediment core samples collected from the deep-sea bottom west of the Izu volcanic islands and from the Izu-Ogasawara Trench has various chemical characteristics similar to the smectites in sediment trap samples (Aoki, 1995). These facts suggest that smectite in this study is transported from various source areas. Fig. 2 shows morphology of smectite in samples which collected by JT-06 at depths of 5,000 m and 9,000 m, respectively. Morphology of the smectite suggests a clastic origin and does not differ as compared with smectite which is derived from the Japanese Islands. Relationship between morphology and chemical compo-
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Fig. 2  TEM figures of smectite. A and B are smectite in sample collected at a depth of 5,000 m and C and D are smectite in sample at a depth of 9,000 m at JT-06, respectively. These symbols correspond to those in Table 2. Bar is 1 micron.

sition of the smectite is not recognized. Yamauchi (1989) reported the presence of radiolaria originating from the Oyashio current flowing southward along the Pacific side of the Japanese Islands. This suggests that clay minerals are transported not only by the Kuroshio current but also the Oyashio current. Chemical analysis of chlorite also shows various characteristics; a tri-octahedral type having a variety of Fe, Mg, and Al cations in the octahedral layer. The origin of chlorite in the present study may be various kinds of rocks such as green-tuff, basic volcanic rocks rich in Fe and Mg, and metamorphic rocks. These rocks and their weathered material are widely distributed on the Pacific side of the Japanese Islands. TEM figures of chlorite in samples which were collected by JT-06 at depths of 5,000 m and 9,000 m are shown in Fig. 3. Morphology of the chlorite exhibits most pillar-shaped and suggests clastic origin. Morphology and chemical
Fig. 3 TEM figures of chlorite. A and B are chlorite in sample collected at a depth of 5,000 m and C and D are smectite in sample at a depth of 9,000 m at JT-06, respectively. These symbols correspond to those in Table 3. Bar is 1 micron.

Composition of the chlorite do not seem to have any relationship.

One of the findings in our previous and present studies is that the order of content of lithogenic minerals contained in the sediment traps is as follows; smectite, illite, quartz feldspar, chlorite, and mafic minerals. The order was the same except for a short duration while these sediment traps were deployed. As to the relationship between the content of each mineral and the water depth, smectite particles tend to increase with increasing of water depth, while the other minerals do not show such a tendency as shown in Table 5. This tendency may be due to the characteristics of the smectite particles, which can be transported horizontally in water longer than the other clay minerals. Honjo et al. (1982), however, observed that smectite in samples of the sediment trap in the Panama Basin increased with
increasing water depth. Their explanation was that smectite floating from the sea bottom was advected by the sea current. In the present study, smectite is considered to have various source areas from the fact that it has relatively high content and from the possibility for the source area for smectite, besides the Japanese Islands, is the Philippine Islands where an important source for smectite is the Philippine sea (Aoki and Oinuma, 1974). In this case the Kuroshio current must play an important role in transporting smectite to the study area.

The second important mechanism of transport to the study area is airborne dust, the loess from mainland China. The loess carried to the Japanese Islands and their neighbouring seas frequently occurs in spring every year. The major sources of the loess in China are the Takula-Makan and Gobi deserts (Tungshen, 1989). The loess from these areas reaches the Japanese Islands in a few days and about 70–80% of the loess falls on the Japanese Islands and sea around the islands (Hydrosphere Institute of Nagoya Univ., 1991). It was found that the average size of the loess is 4 microns and the principal minerals of the loess are illite, quartz, kaolinite, and chlorite which are deposited on the sea bottom around the Japanese Islands (Inoue et al., 1991 and 1993). The loess from mainland China is the major source of the Pacific sediment, particularly in the northwestern Pacific, as demonstrated by Duce et al., 1980; Rea et al., 1985; Blank et al., 1985; Gao et al., 1992; Nakai et al., 1993. The authors discussed the sinking velocity of the loess to the bottom of the Japan Trench from the relationship between the illite and quartz content in samples from the sediment traps, which are the major lithogenic minerals of the loess as discussed in the previous paper (Aoki and Kohyama, 1992). TEM figures of illite and quartz in samples collected by JT-6 at a depth of 5,000 m are shown in Fig. 4. The relationship between illite and quartz content in samples of each sediment trap is shown in Figs. 5 to 8. Fig. 5 shows a positive relationship.

Table 5  Relationship between amount of major mineral particles and the depth of each sediment trap.

<table>
<thead>
<tr>
<th>Sample</th>
<th>smectite</th>
<th>illite</th>
<th>chlorite</th>
<th>quartz</th>
<th>feldspar</th>
</tr>
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<tbody>
<tr>
<td>JT-05-5035 m</td>
<td>520</td>
<td>248</td>
<td>101</td>
<td>202</td>
<td>146</td>
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<tr>
<td>JT-05-8544 m</td>
<td>486</td>
<td>340</td>
<td>92</td>
<td>190</td>
<td>140</td>
</tr>
<tr>
<td>JT-06-5000 m</td>
<td>485</td>
<td>332</td>
<td>89</td>
<td>188</td>
<td>130</td>
</tr>
<tr>
<td>JT-06-9000 m</td>
<td>420</td>
<td>288</td>
<td>112</td>
<td>226</td>
<td>152</td>
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<tr>
<td>JT-07-1000 m</td>
<td>399</td>
<td>258</td>
<td>103</td>
<td>290</td>
<td>180</td>
</tr>
<tr>
<td>JT-07-3500 m</td>
<td>391</td>
<td>224</td>
<td>91</td>
<td>265</td>
<td>185</td>
</tr>
<tr>
<td>JT-07-5500 m</td>
<td>357</td>
<td>260</td>
<td>123</td>
<td>240</td>
<td>170</td>
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</tbody>
</table>
Fig. 4 TEM figures of illite and quartz. A and B are illite, and C and D are quartz. Both of minerals are in samples collected at a depth of 5,000 m of JT-06. Symbols A and B correspond to those in Table 4. Bar is 1 micron.

between illite and quartz content in samples collected by JT-04 at a depth of 4,235 m, which they suggest originates from the loess. Illite and quartz content in sample of JT-05 collected at a depth of 5,035 m shows somewhat positive relationship but is a negative as a whole as shown in Fig. 6. The same interpretation is made for the relationship between illite and quartz content in samples collected at a depth of 5,000 m clearly shows a negative relationship, while samples collected at a depth of 9,000 m exhibit a positive relationship overall as shown in Fig. 7. Fig. 8 shows the relationship between illite and quartz content in samples collected by JT-07 at depths of 1,000, 3,500, and 5,500 m, respectively. The upper two diagrams show a negative relationship whereas the lowest one exhibits a positive relationship as a whole.

The results obtained from the relationship between the illite and quartz content
Fig. 5 Relationship between illite and quartz contents in sample JT-04.
in samples collected various depths by JT-04 to 07 show that illite and quartz in samples collected by JT-04 at depths of 4,235 m, by JT-06 at 9,000 m, and JT-07 at 5,500 m seem to have been transported from mainland China, but other trap samples do not show any relation to the loess. Aoki and Kohyama (1992) inferred from the velocity of sinking to the bottom of the Japan Trench using the good relationship between the content of illite and quartz in samples collected by JT-02 at a depth of 8,700 m that they reached the bottom within one year together with marine snow. However, the present study does not necessarily show such a result,
but rather a negative relationship as a whole. Other factors may have affected the lithogenic mineral composition contained in samples of the sediment traps in this study. Okada (1992) confirmed the presence of reworked species of nanofossils in sample collected by JT-07 at depths of 5,500 and 3,500 m. He suggested it was due to a submarine earthquake. In addition, many benthic foraminifera are contained in samples of JT-03, 04, and 05 (Oda, personal communication). Honjo (1989) observed almost five times the average lithogenic minerals in suspended matter
Fig. 8  Relationship between illite and quartz contents in sample JT-07.
heaved up from the sea bottom by the turbidity current must dilute the lithogenic minerals sinking through the water column.

**SUMMARY AND CONCLUSION**

Eight sediment traps were deployed at different depths of the Japan Trench during the period of November 1988 to March 1992 and 104 samples were collected from the traps. One hundred mineral particles contained in each sample were identified by means of ATEM, so the total number of minerals identified amounts to 10,400 particles. The results and conclusion are summarized as follows.

1. Thirteen kinds of minerals were identified; five clay mineral and eight non-clay minerals. Smectite and illite are the dominant clay minerals, which have the maximum and minimum content ranging from 37 to 27% and 35 to 17%, respectively. Quartz is the most abundant non-clay mineral, which has the maximum and minimum content ranging from 22 to 14%.

2. Chemical analyses of clay minerals show a variety of characteristics. Smectite is grouped into a tri-octahedral Fe-Mg saponite, a di-octahedral Fe-Mg beidellite, and Al-Femontmorillonite. Chlorite is divided into two types; a tri-octahedral Fe-Mg type and Fe-Mg-Al type. Illite is a di-octahedral type rich in potassium.

3. The lithogenic mineral composition and chemical composition of the clay minerals suggest that they have various source areas, not only from the Japanese Islands close to the sediment trap site but also from the Philippine Islands and mainland China.

4. The transport mechanism of lithogenic minerals from the Japanese Islands and Philippine Islands is by rivers and the Kuroshio current. In some cases the turbidity current and Oyashio current may play a role in transporting these lithogenic minerals. However, some illite and quartz in the present samples originated from the loess and was transported from mainland China by the wind.

5. The relationship between the content of illite and quartz in samples collected from different depths by JT-04 to 07 does not necessarily support the previous conclusion that illite and quartz in samples collected by JT-02 at a depth of 8,700m originated from the loess and reached the bottom of the Japan Trench within one year together with marine snow.

6. A negative relationship between the content of illite and quartz in the present samples seems to be attributed to some factors such as the dilution effect by the influx of other lithogenic minerals heaved from the sea bottom.

7. Decreasing of smectite abundance with increasing water depth indicates that smectite tends to move horizontally longer than other clay minerals.
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