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海底写真による駿河舟状海盆の生痕

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Lebensspuren Photographed on the Deep-Sea Floor of Suruga Bay, Central Japan

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This paper presents underwater photographs of lebensspuren taken at 6 stations from depths of 500m to 2800m in Suruga Bay, central Japan (Fig. 1). Stations 1 to 3 are located in a valley-like depression called the Suruga Trough and two other sites (Stations T_1 and T_2) were selected on the eastern slope of the Trough (Fig. 1 and Table 1).

The lebensspuren in deeper areas (Stations 1 to 3 ; 2036 to 2820m deep) tend to be characterized by shallow-burrowers, whereas those in shallower areas tend to be characterized by deep-burrowers. The bathymetric control of lebensspuren advocated by SEILACHER (1967), however, cannot be applied directly to the present case. In the case of this coastal deep bay, bottom sediments and water characteristics seem to control the ichnofauna more effectively than water depth and food amounts, which are generally closely related.

1．まえがき

堆積物中に記録された動物体の活動の跡である生痕(Lebensspuren)は動物の生活活動様式を示すだけでなく環境推定の有力な手がかりを与えるものとして極めて重要である．とくに過去の地層を扱う場合，体化石が認められない時でも生痕はかなりよく保存されており，しかも現地成(in situ)を示すので，近年地層の堆積環境復元のために生痕化石群の研究はますます重視されている．

生痕化石をこのような目的のために有効に利用するには，生痕とその造形主との対応をつけやすい現在の海底の諸環境で生痕相をできるだけ詳しく解析しておく必要がある．そのような研究は，遠洋深海底でも深海カメラの発達(例えば，EWING and DAVIS, 1967; HEEZEN and HOLLISTER, 1971)や最近の深海掘削計画(Deep Sea Drilling Project / International Phase of Ocean Drilling)の進展に伴い着

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実な成果を挙げている(WARME *et al.*, 1973 ; VAN DER LINGEN, 1973; CHAMBERLAIN, 1975; EKDALE, 1977, 1978; など).

本報告では駿河湾を南北に走る駿河舟状海盆中軸部の水深1000m以深の4地点および水深500～700mの2地点で撮影した海底写真約3000駒のうち生痕相をよく示している代表的な写真58葉を選んで，地点による生痕群集の特徴を示し，過去の地層研究のための一指標にしたい.

2．海底写真の撮影および撮影地点

本報告に用いた海底写真の撮影は1977年6月7日から6月12日にかけて，東京大学海洋研究所共同利用調査船「淡青丸」による調査航海KT-77-7(主席研究員：堀越増興・岡田博有)で行われた.

海底写真の撮影および解析は太田が行った．撮影に用いたカメラはEC & G製モデル200Aの改造型で，レンズはHopkins F4.5であり，光源には100w/secのストロボを使った．カメラは同じ規格のものを2本光軸を平行にしてステレオ写真をとり，撮影画面はステレオペア毎にステレオ解析を行って，画面サイズ，被写体の大きさを決定した．一度のカメラの降下により，6秒毎の露出で約600対のステレオ写真が得られる．なお，海底直上にカメラを保持するため，カメラ枠にピンガー〔EG & G製モデルMK-1〕を装着し，この直達音と反射音の時間差から撮影距離を測定しつつウィンチ操作を行った(OHTA, 1976).

海底写真撮影地点は駿河舟状盆中軸線上で4点(いずれも水深1000m以深)，湾奥の東側斜面上の2点(水深500～800m)であり，それらの詳細はFig. 1とTable 1に示すとおりである.

3．生痕群集の特徴

a. 地点1：この地点は駿河舟状海盆の中では最も幅が広く，水深も深い(Fig. 1). 海底面は非常に平坦で，泥質である．部分的に底層流の影響を示唆する砂漣(ripple mark) (Pl. 3, Fig. 2), 流水によるうね状地形(Pl. 4, Fig. 1), 線構造(Pl. 3, Fig. 2)がみられる．さらに注意すべき現象として，海底面全体にガスの逸出孔と思われる小ピットが無数に認められる(Pl. 1; Pl. 2, Fig. 2; Pl. 3, Fig. 1; Pl. 4, Fig. 1). 海底面上の生物にはチヒロエビ類がときどき見られる.

生痕の分布密度は一般に低く，生痕がほとんど写っていない写真もある．しかし，時どき短い棒状のゴカイ類の棲管が密集していることがある(Pl. 2, Fig. 1). 這い跡は少ないけれども，二枚貝か巻貝によると思われる曲線状(Pl. 1, Fig. 2), 直線状，フック状のものがみられ，非連続的足跡としてタラバガニ類(？)の這い跡が観察される (Pl. 2, Fig. 2).

b. 地点2：この地点は駿河湾口の水深2555mの駿河舟状海盆軸部にあたる(Fig. 1). 海底面は地点1と同様に平坦で，泥質である．海底付近の水中にはかなり多くのクシクラゲ類が認められるほか，ホラアナゴの仲間(*Synaphobranchus* sp.)が1個体みられた.

ここでもガス逸出孔(?)が多数認められる．生痕密度は低い．Pl. 4, Fig. 2には二枚貝か巻貝によると思われる連続的な這い跡が顕著である.

地点2の群集は地点1に似ている.

Table 1. Location, time of sampling and characteristics of the underwater camera stations.

Station No.	Area	Date	Time	Ship Position	Depth	Surface Temp.
1	Off Suruga Bay	7 June, 1977	15:57-16:55	34°24.8′N, 138°33.7′ －34°24.8′N, 138°33.7′E	2813-2820m	23.7℃
2	Mouth of Suruga Bay	12 June, 1977	16:24-16:33	34°33.8′N, 138°35.0′E	2555m	22.8℃
3	East of Senoumi	8 June, 1977	14:05-15:05	34°42.6′N, 138°35.1′E－34°42.9′N, 138°35.3′E	2036-2056m	22.8℃
4	Off Heta	9 June, 1977	13:15-14:15	34°59.1′N, 138°40.2′E－34°59.5′N, 138°40.6′E	1380-1427m	
T_1	Off Toi	10 June, 1977	14:45-15:47	34°55.2′N, 138°42.7′E－34°55.6′N, 138°42.9′E	509- 580m	23.2℃
T_2	Off Toi	11 June, 1977	10:10-11:07	34°55.3′N, 138°41.7′E－34°55.7′N, 138°42.1′E	694- 790m	23.9℃

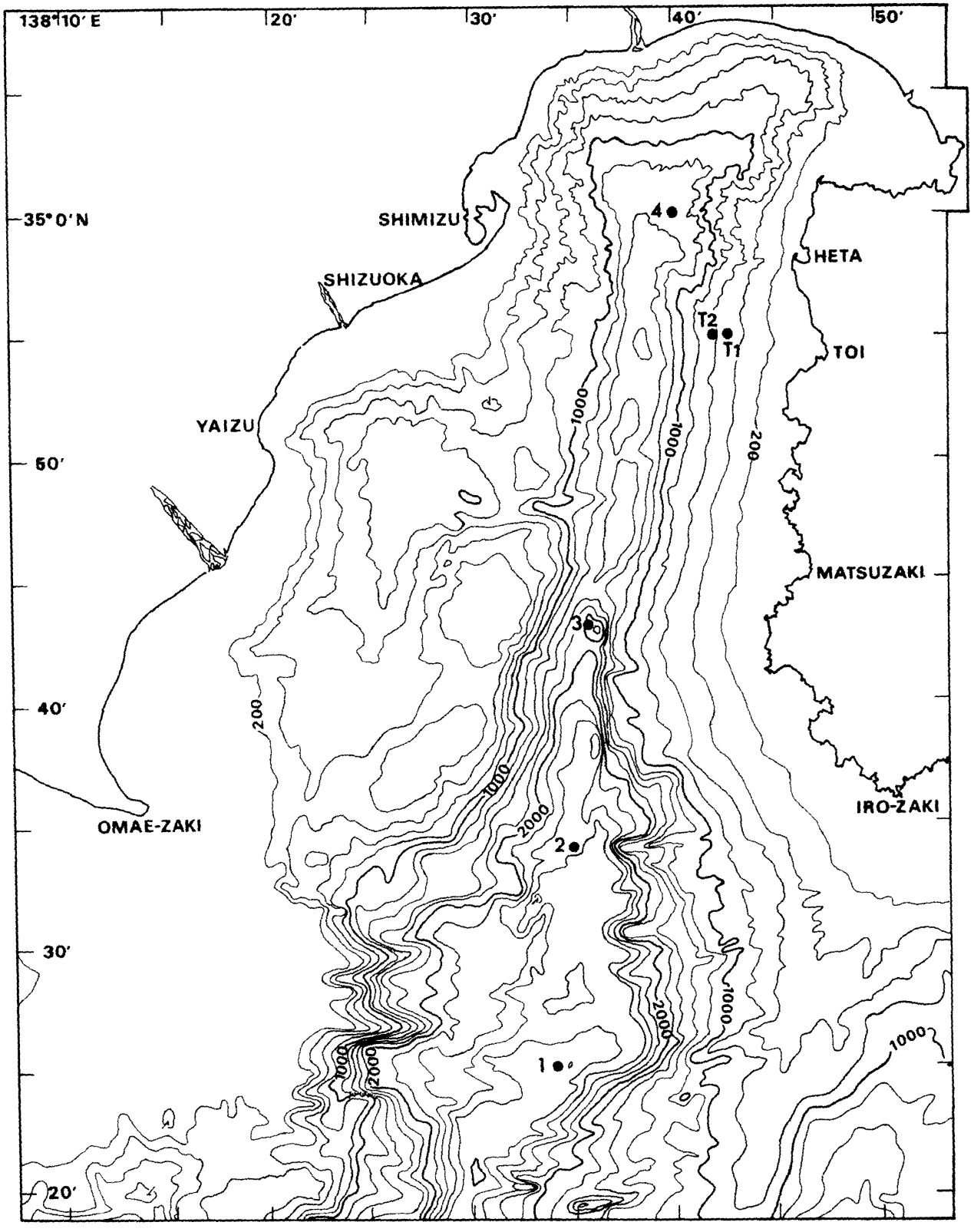

Fig. 1. Bathymetric map of Suruga Bay showing locations of the underwater camera stations during the cruise KT-77-7 of R/V Tansei-Maru. Depth in m.

c. 地点 3：地点 3 は駿河舟状海盆中軸部の幅が狭くなった場所で，小盆状地形の所にあたる．水深は 2036～2056m である(Fig. 1).

海底面は平坦で，一様な泥質堆積物でおおわれている．海底にはエビやエイ(*Bathyraja* sp.)が認められることがある．一般に，ほぼ南北方向の線構造が顕著である(Pls. 5, 6, 7, 8)が，これは底層流によるものと思われる．とくに，Pl. 6, Fig. 2 には中礫の囲りに洗い掘り構造がみられる．

生痕の分布密度は一般にかなり高い．最もふつうの生痕はゴカイ類の棲管(Pls. 5, 7, 8)で，これはかなり広く散在している．連続的な滑り跡として興味ある構造(Pl. 7, Fig. 2; Pl. 8, Figs. 1, 2)は雄のソコガンギエイ(*Bathyraja* sp.)の一対の交尾器によって作られたものである．なお，Pl. 7, Fig. 1 に写っているエイは雌である．造形主不明の構造も認められる(Pl. 6, Fig. 1).

d. 地点 4：この地点は富士川河口沖の水深 1380～1427m，駿河舟状海盆中軸部の北端に当たる(Fig. 1). 海底面は泥質堆積物でおおわれ，mound や pit による小起伏に富んだ微地形で特徴づけられている．それらが底層流によって変形され，砂漣を形成していることがある(Pl. 9, Fig. 1 ; Pl. 13, Fig. 2). その流れはほぼ北から南に向っている．

海底面にみられる生物にはムラサキハゲナマコ(*Pannychia moseleyi* THEEL, 1882)が圧倒的に多く(Pl. 9, Fig. 1; Pl. 10, Fig. 1),まれにユメナマコ(*Enypiastes eximia* THEEL, 1882) (Pl. 11, Fig. 1)やエゾイバラガニ(*Paralomis multispina* BENEDICT, 1885) (Pl. 11, Fig. 2)が認められる．

生痕の分布密度は高い．そのうち這い跡はほとんどムラサキハゲナマコによるもので，他にユメナマコによる鋭い引っかき跡(Pl. 11, Fig. 1), エゾイバラガニの足跡(Pl. 11, Fig. 2), クモヒトデ(ophiuroids)の這い跡(Pl. 13, Fig. 1)などが認められる．また無数の円錐状ないしはドーム状の構造およびそれらの間に点在する深い穴は，前者がゴカイ類の，後者がブンブク類によって作られたものかもしれない(Pl. 11, Fig. 2).

e. 地点 T_1：この地点は駿河舟状海盆中軸部の北端に近い東側斜面に位置しており，水深は509～580 m である．海底は泥質で，mound や pit に富んだ複雑な微地形を示す．海底面の生物にはウシナマコ(*Peniagone japonica* OHSHIMA, 1915) (Pl. 21, Fig. 1), ごかい(*Aphrodita aculeata* LINNAEUS, 1761) (Pl. 21, Fig. 1), スルガバイ(*Buccinum leucostoma* LISCHKE, 1872), リュウコツクモヒトデ(*Ophiochiton fastigatus* LYMAN, 1878) (Pl. 20, Fig. 2), ギンエビスガイ(*Ginebis argenteonitens argenteonitens* LISCHKE, 1872) (Pl. 29, Fig. 2), 単体サンゴ(Pl. 20, Fig. 1), 海えら類(Pl. 17, Figs. 1, 2; Pl. 19, Figs. 1, 2)などが確認された．

生痕の分布密度はかなり高い．代表的な生痕は海底面直下を潜行するブンブク(*Lovenia gregalis* ALCOCK, 1893)のモグラ状掘進跡である(Pl. 15, Figs. 1, 2; Pl. 29, Fig. 1). カゴウニ(*Phormosoma bursarium* A. AGASSIZ, 1881) (Pl. 16, Fig. 2; Pl. 18, Fig. 2)やスルガバイ，ギンエビスガイの跡も顕著である(Pl. 19, Fig. 2; Pl. 20, Fig. 2; Pl. 21, Fig. 1; Pl. 29, Fig. 2). リュウコツクモヒトデの穴も著例である．その他，放射状の構造(Pl. 19, Figs. 1, 2)や生物体が不明の糞塊(Pl. 17, Fig. 2)も興味深い．

f. 地点 T_2：この地点は T_1 地点に近い水深 694～790m の場所である．海底は泥質で，生痕の発達が著しい．海底の生物にはウルトラブンブク(*Linopneustes fragilis* (DE MEIJERE, 1902))が豊富で，ウシナマコ，クサイロギンエビスガイ(*Bathybembix aeora* (WATSON, 1879)) (Pl. 25, Fig. 2), キヌクシノハクモヒトデ(*Ophiura flagellata* (LYMAN, 1878)), ホソホシガタヒトデ(*Zoroaster ophiactis* FISHER, 1916) (Pl. 28, Fig. 1), アネモネ(Pl. 26, Fig. 1), サガミハラブトツノガイ(*Gadila sagamiensis* KURODA and HABE, 1971)などが認められる．

生痕としては当然ウルトラブンブクの這い跡が顕著で，明瞭な巻貝の這い跡も少なくない(Pl. 23, Fig.

2; Pl. 25, Fig. 2; Pl. 28, Fig. 2). その他ホソホシガタヒトデ(Pl. 28, Fig. 1)や正体不明の糞塊(Pl. 26, Figs. 1, 2; Pl. 27, Figs. 1, 2)などが注目される.

4. 考　察

生痕群集の解析により，過去の地層の堆積環境を復元しようとする試みは，SEILACHERによる先駆的研究(例えば，1959, 1967, 1974)以来多彩な成果が挙がっている．とくに現在の海洋底の深海カメラによる情報量が飛躍的に増大し，現在と過去の生痕群集の比較研究が格段と進展した．SEILACHER (1959)はフリッシュ相とモラッセ相の生痕群集の研究から，生痕群集が水深指示者(depth indicator)として有効であることを一般化して(SEILACHER, 1967; 1974)，地層の古環境研究の発展を促した．ところで，生痕群集の深度規制が常に成立するかどうかについては，現在の底生生物の生態研究，とくに深海カメラによる生痕群集の解析からの反論がある(例えば，KITCHELL *et al.*, 1978).

駿河湾深海域の海洋構造は不明な点が多く，本報告で示した生痕群集を規制する要因を明らかにすることは現時点では容易でない．ただ，測点間の生痕群集の特徴を概括すると，比較的浅い測点では堆積物内に潜る内生生物の生活痕が目立ち，生活痕が互いに錯綜するのに対し，水深が深くなるにつれて泥層を浅く利用する生活痕が多くなっているように思われる．

駿河湾における多数回のトロール曳網と深海用水中ステレオカメラを駆使した生物群集の研究では，底生生物群集の水深に沿った明瞭な推移が示唆されているにもかかわらず(太田，未発表)，生物の生活形を主要な基礎とする生活痕群集の深度に沿った推移を明らかにすることは困難であった．

本報告の駿河湾の調査地点間の海底環境および水深差があまり広範ではなく，SEILACHERの深度規制の尺度をこの場に直接適用するには困難がある．また駿河湾が極めて深度勾配の大きい漸深海系であるため，陸からの距離が小さく，水深の増大と栄養物質の減少が他の海域で報告されている程大きな逆比例関係が認められない．これに駿河湾の海底地形の単調さも加わり，底質ひいては生物の生息環境の多様性が小さく，深度差の大きい割には生物群集の生活形に顕著な差が生じていないのではなかろうか.

上の考察でも示唆されるように生痕化石学と現生の生物群集解析の立場および方法論の相違にも注意しなければならない．現生の生物群集の研究では形態学的な差異をもとに分類・同定された種の群集を取り扱うのに対し，生痕化石学では生物の行動あるいは生態が強調され，環境要因が論じられている．また従来の深海底生物の生態学的研究がその作業の困難さにより平面的な解析にとどまっていたのに対し，生痕化石の研究では立体的な解析および時間スケールが含められており，これら両者の立場を同一次元で単純に比較できないことを考慮に入れなければならない.

この事例研究からいえることは，生痕の深度規制の考え方を生痕化石による地層の堆積環境復元に適用するに当たっては注意を要することである.

謝　辞

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Plate 1 ~ 29

Plate 1. Bottom photographs taken at Station 1, KT-77-7.

Fig. 1. Flat surface with a few decaying faecal casts made by holothurians. Evenly scattered dots seem to be gas-pits. The black needle of the compass points to the north.
Water depth : 2847m, date : June 7, 1977, time : 16:34'38".
The vertical length of the photo spans a distance of 75.5 cm on the sea floor.

Fig. 2. Track of either a pelecypod or gastropod. Also note number of gas-pits (?).
Water depth : 2843m, date : June 7, time : 16:12'14".
The vertical length of the photo spans a distance of 72.2 cm on the sea floor.

Fig. 1

Fig. 2

Plate 2. Bottom photographs taken at Station 1, KT-77-7.

Fig. 1. Scattered annelid tubes. The black needle of the compass points to the north.
Water depth : 2846m, date : June 7, 1977, time : 16:27'50".
The vertical length of the photo spans a distance of 100.1 cm on the sea floor.

Fig. 2. Imprints probably made by the podia of a stone crab.
Water depth : 2844m, date : June 7, 1977, time : 16:19'26".
The vertical length of the photo spans a distance of 75.7 cm on the sea floor.

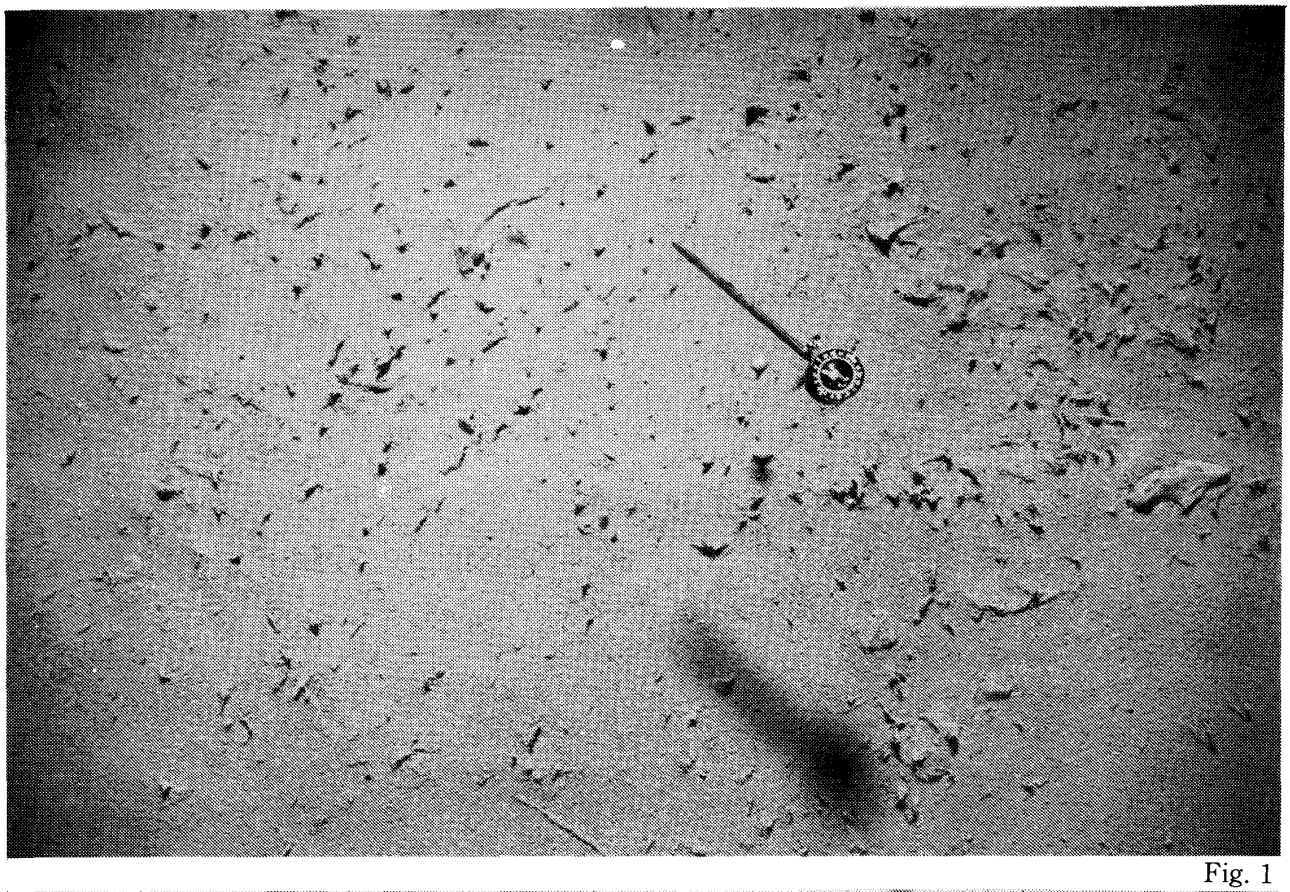

Fig. 1

Fig. 2

Plate 3. Bottom photographs taken at Station 1, KT-77-7.

Fig. 1. Faecal casts of holothurians in the upper right have been smoothed by bottom currents. The black needle of the compass points to the north.
Water depth : 2849m, date : June 7, 1977, time : 16:42'14".
The vertical length of the photo spans a distance of 103.6 cm on the sea floor.

Fig. 2. Current lineations and ripple mark (?). Faecal casts of holothurians are seen.
Water depth : 2847m, date : June 7, 1977, time : 16:33'14".
The vertical length of the photo spans a distance of 60.2 cm on the sea floor.

Fig. 1

Fig. 2

Plate 4. Bottom photographs taken at Station 1 (Fig. 1) and Station 2 (Fig. 2), KT-77-7.

Fig. 1. Current mark lying parallel to the axis of the Suruga Trough (N-S). Decaying faecal casts of holothurians are scattered.
Water depth : 2847m, date : June 7, 1977, time : 16:31'32".
The vertical length of the photo spans a distance of 93.4 cm on the sea floor.

Fig. 2. Mollusc trails and a few faecal casts of holothurians (in the bottom of the photo) are seen.
Water depth : 2570m, date : June 12, 1977, time : 16:29'52".
The vertical length of the photo spans a distance of 257.8 cm on the sea floor.

Fig. 1

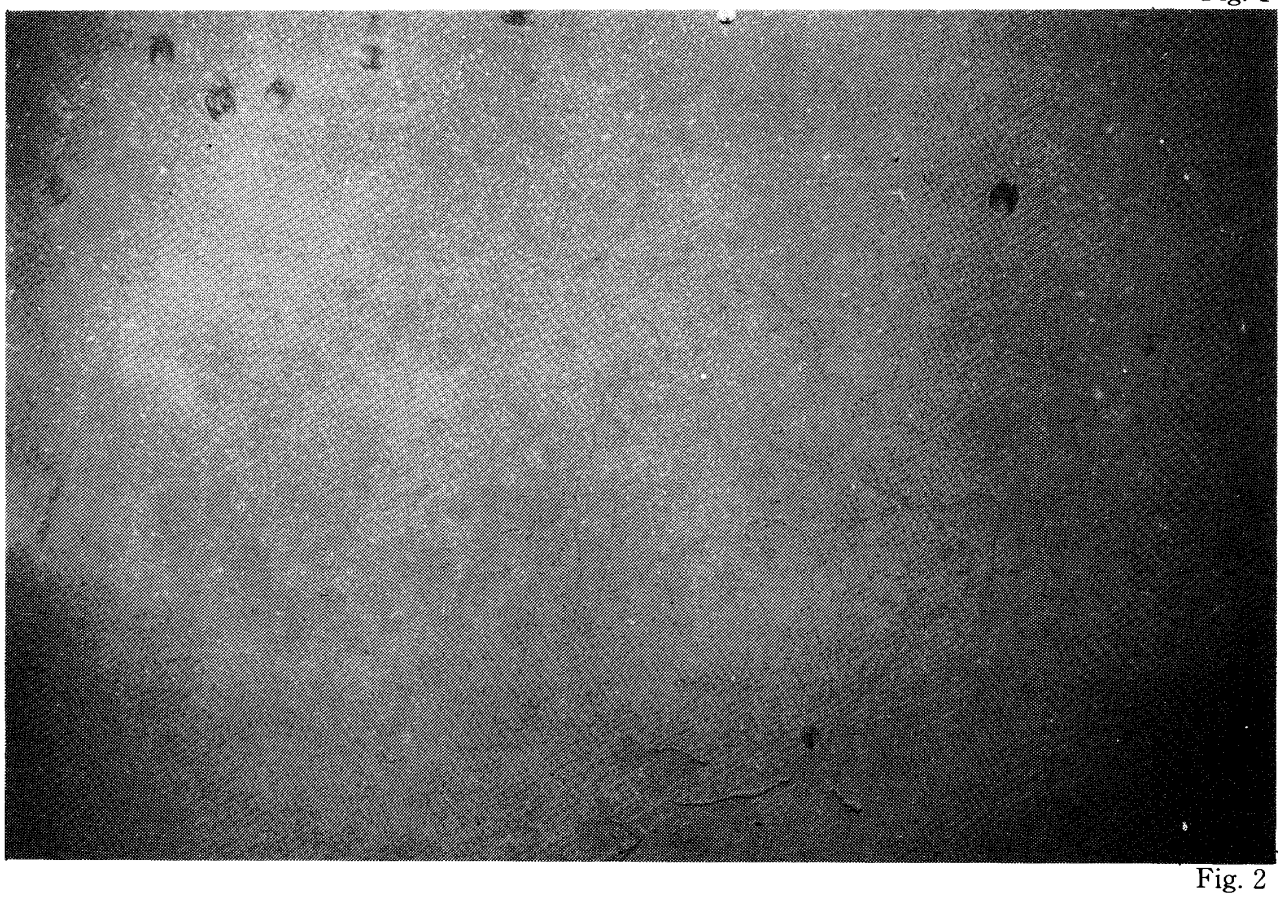

Fig. 2

Plate 5. Bottom photographs taken at Station 3, KT-77-7.

Fig. 1. Annelid tubes.
Water depth : 2049m, date : June 8, 1977, time : 14:20′45″.
The vertical length of the photo spans a distance of 142.0 cm on the sea floor.

Fig. 2. Annelid tubes.
Water depth : 2050m, date : June 8, 1977, time : 14:17′39″.
The vertical length of the photo spans a distance of 68.3 cm on the sea floor.

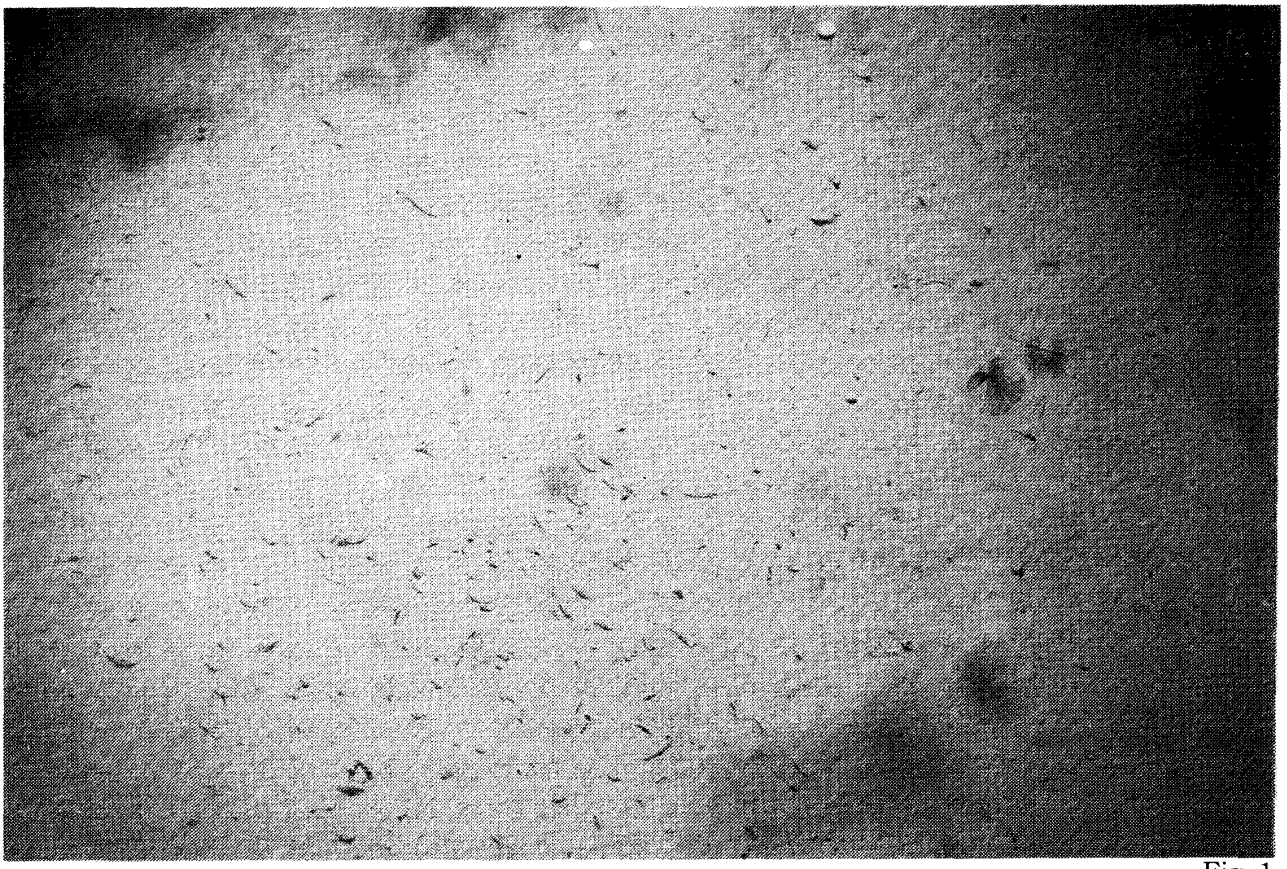

Fig. 1

Fig. 2

Plate 6. Bottom photographs taken at Station 3, KT-77-7.

Fig. 1. Holes of unknown origin.
Water depth : 2051m, date : June 8, 1977, time : 14:16'15".
The vertical length of the photo spans a distance of 40.0 cm on the sea floor.

Fig. 2. Current scour around a cobble.
Water depth : 2036m, date : June 8, 1977, time : 15:00'15".
The vertical length of the photo spans a distance of 61.4 cm on the sea floor.

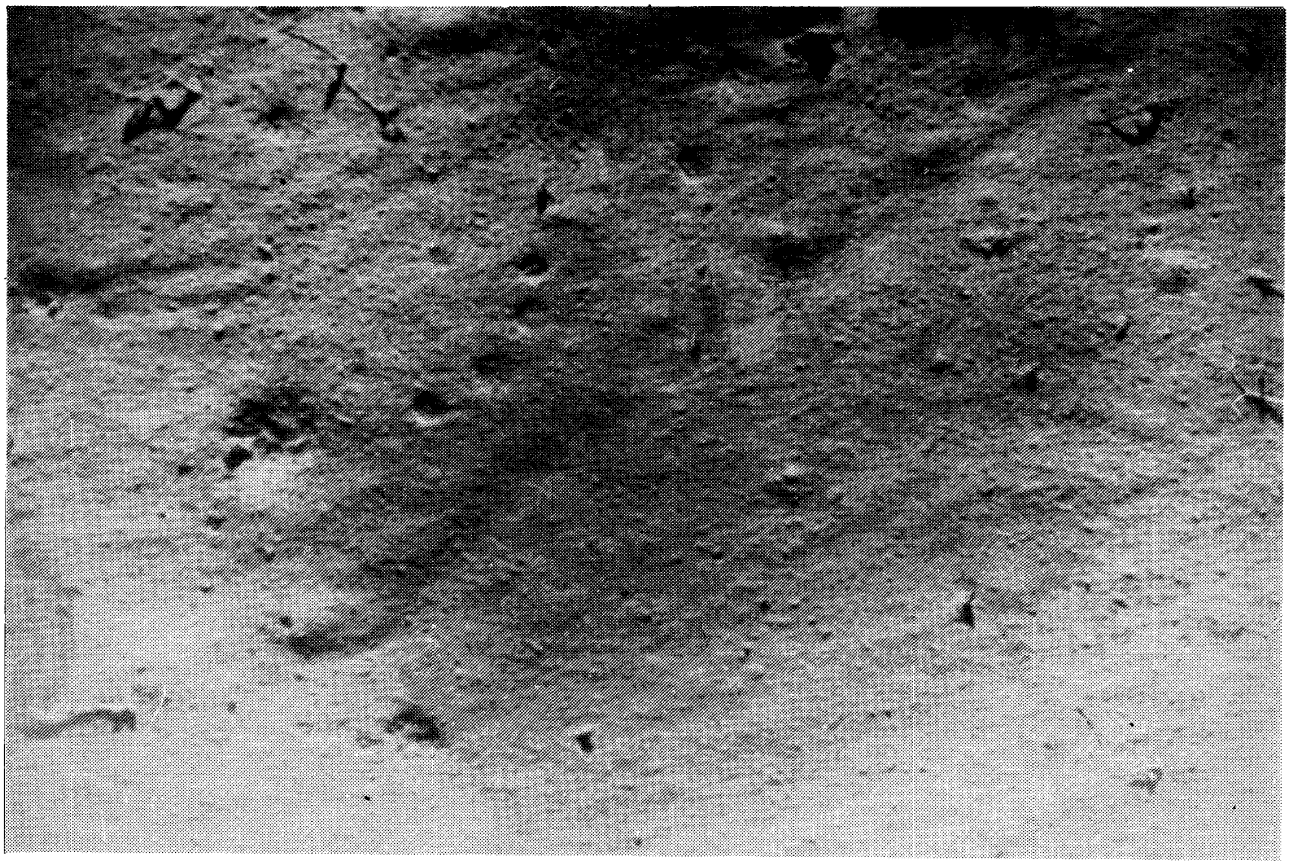

Fig. 1

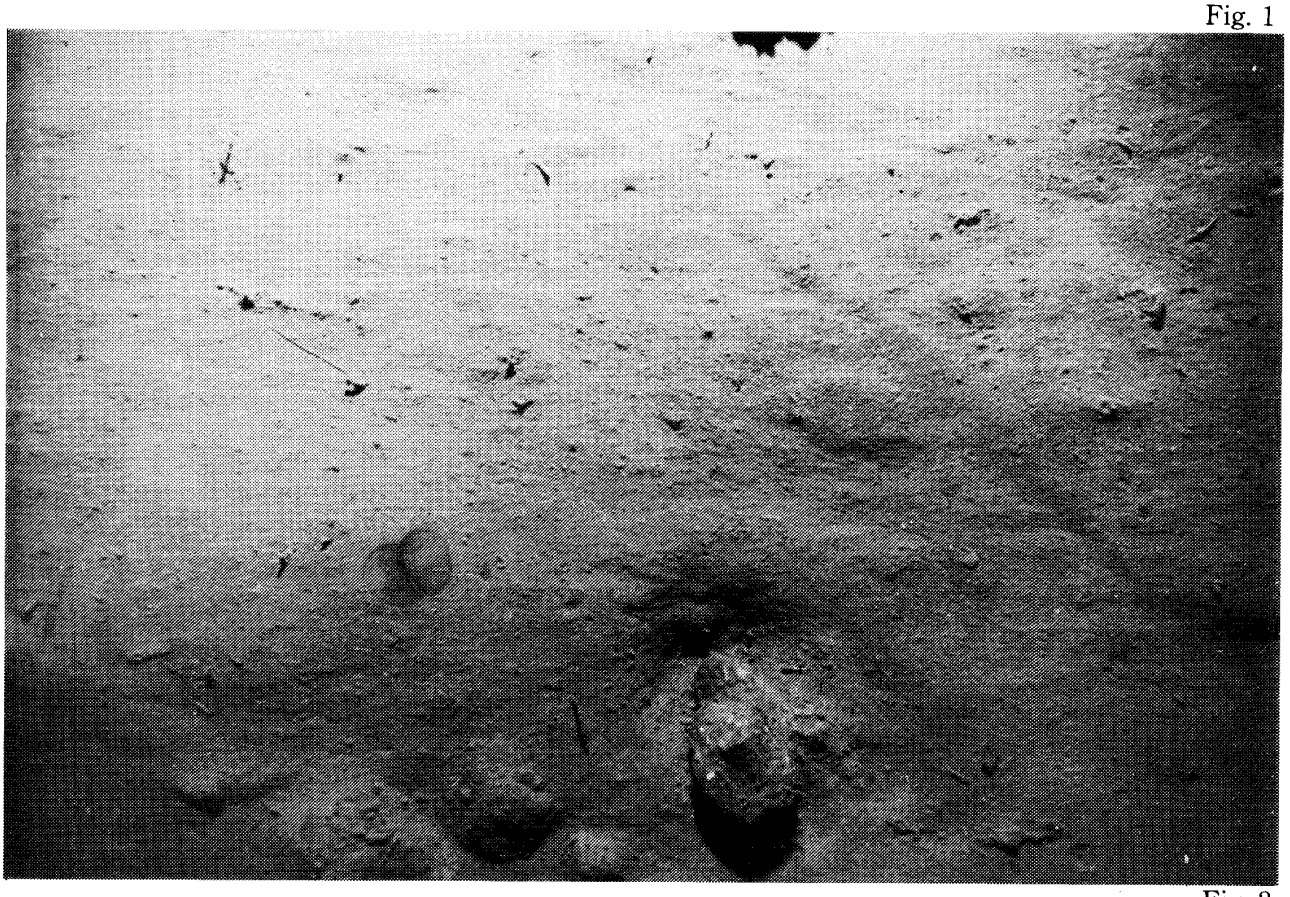

Fig. 2

Plate 7. Bottom photographs taken at Station 3, KT-77-7.

Fig. 1. A female skate (*Bathyraja* sp.) rests on the mud bottom with many annelid tubes. A curved stick in the centre of the photo is of unknown origin.
Water depth : 2045m, date : June 8, 1977, time : 14:34′33″.
The vertical length of the photo spans a distance of 133.0 cm on the sea floor.

Fig. 2. A set of two parallel grooves created possibly with cluspers of a male skate (*Bathyraja* sp.).
Water depth : 2048m, date : June 8, 1977, time : 14:24′57″.
The vertical length of the photo spans a distance of 96.5 cm on the sea floor.

Fig. 1

Fig. 2

Plate 8. Bottom photographs taken at Station 3, KT-77-7.

Fig. 1. Trails probably created by a male skate. Broken pieces of either wood or bamboo are attached by tiny deep-sea molluscs, over which a male skate crossed.
Water depth : 2048m, date : June 8, 1977, time : 14:25′21″.
The vertical length of the photo spans a distance of 81.0 cm on the sea floor.

Fig. 2. Trails probably created by male skates, and many annelid tubes.
Water depth : 2047m, date : June 8, 1977, time : 14:28′33″.
The vertical length of the photo spans a distance of 103.0 cm on the sea floor.

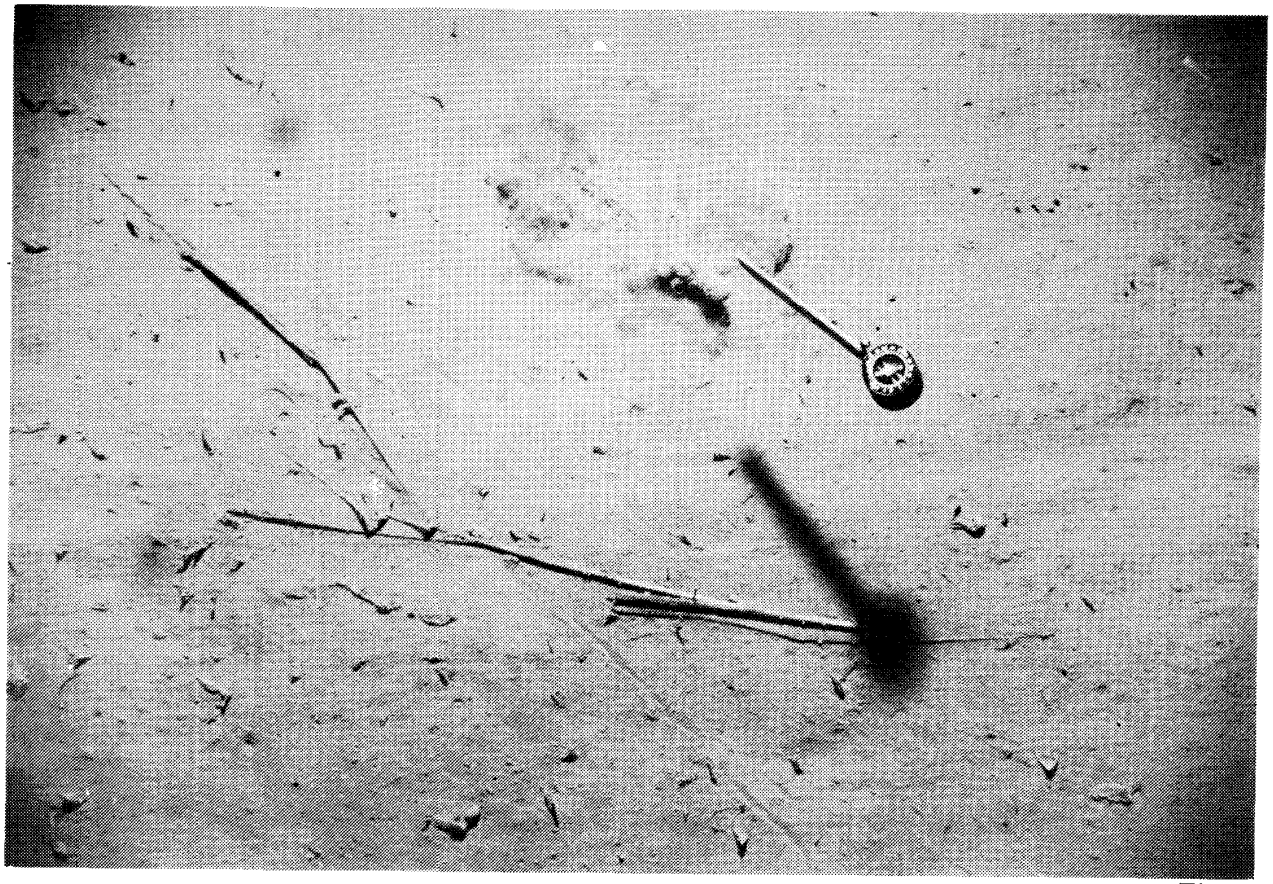

Fig. 1

Fig. 2

Plate 9. Bottom photographs taken at Station 4, KT-77-7.

Fig. 1. Two holothurians (*Pannychia moseleyi* THEEL, 1882) and their trails. Note lunate ripple marks in the lower right. Bottom currents flow from north to south.
Water depth : 1400m, date : June 9, 1977, time : 13:55'13".
The vertical length of the photo spans a distance of 118.2 cm on the sea floor.

Fig. 2. Trails of holothurian, *Pannychia moseleyi* and its faecal casts.
Water depth : 1415m, date : June 9, 1977, time : 13:27'07".
The vertical length of the photo spans a distance of 80.5 cm on the sea floor.

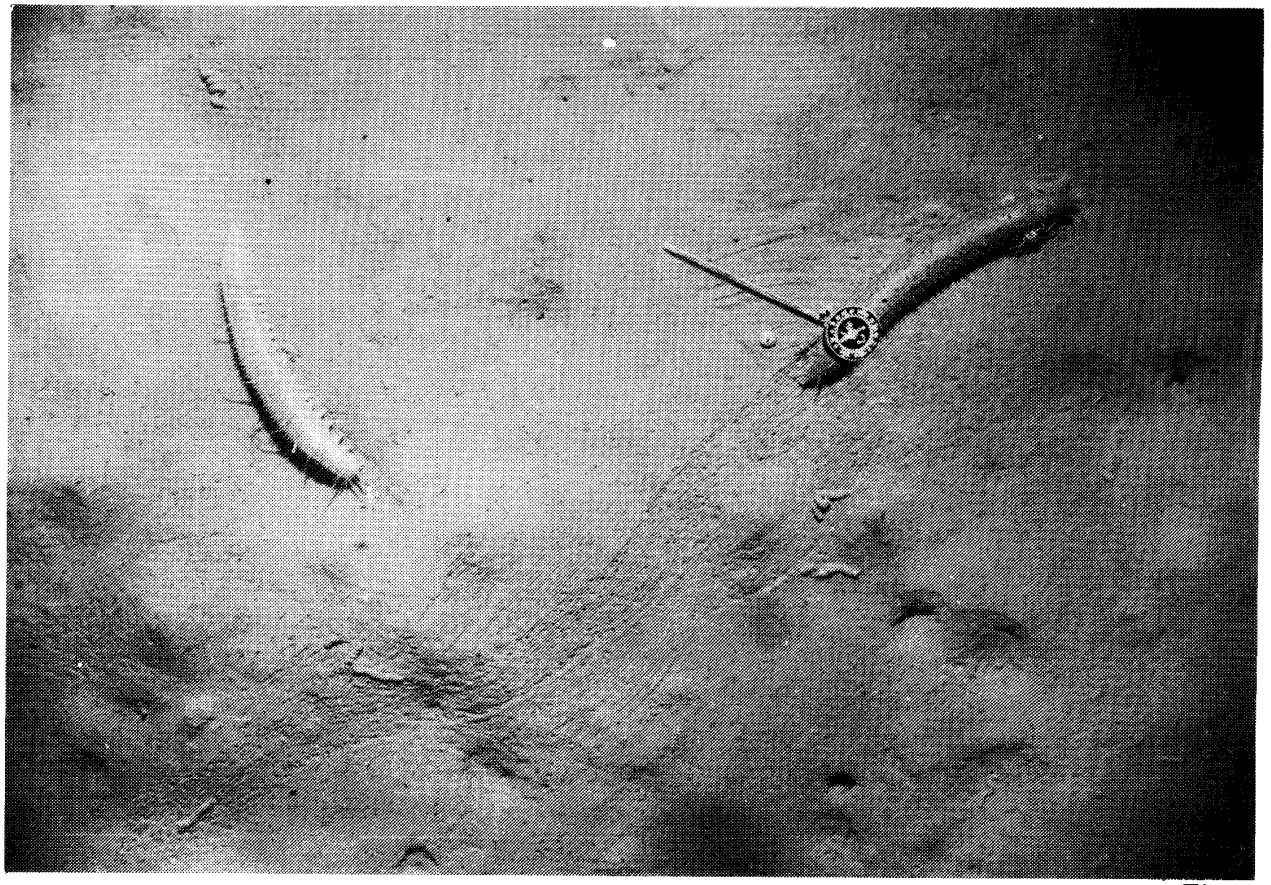

Fig. 1

Fig. 2

Plate 10. Bottom photographs taken at Station 4, KT-77-7.

Fig. 1. A holothurian (*Pannychia moseleyi*) is changing course of its movement. At a turning point scratches are produced.
Water depth : 1400m, date : June 9, 1977, time : 13:56'25".
The vertical length of the photo spans a distance of 87.4 cm on the sea floor.

Fig. 2. Holothurian trail with a feature created at the time of turn of its movement direction.
Water depth : 1400m, date : June 9, 1977, time : 13:54'13".
The vertical length of the photo spans a distance of 102.4 cm on the sea floor.

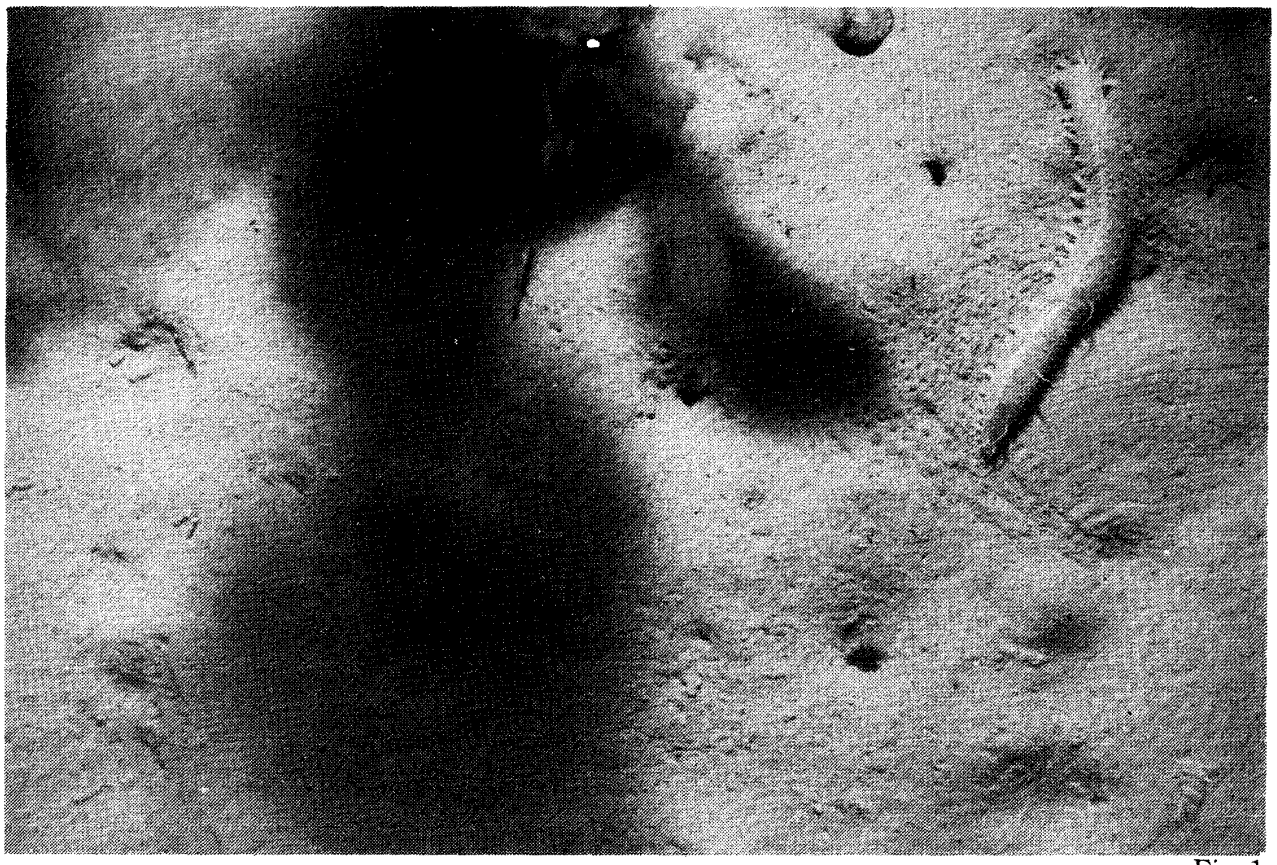

Fig. 1

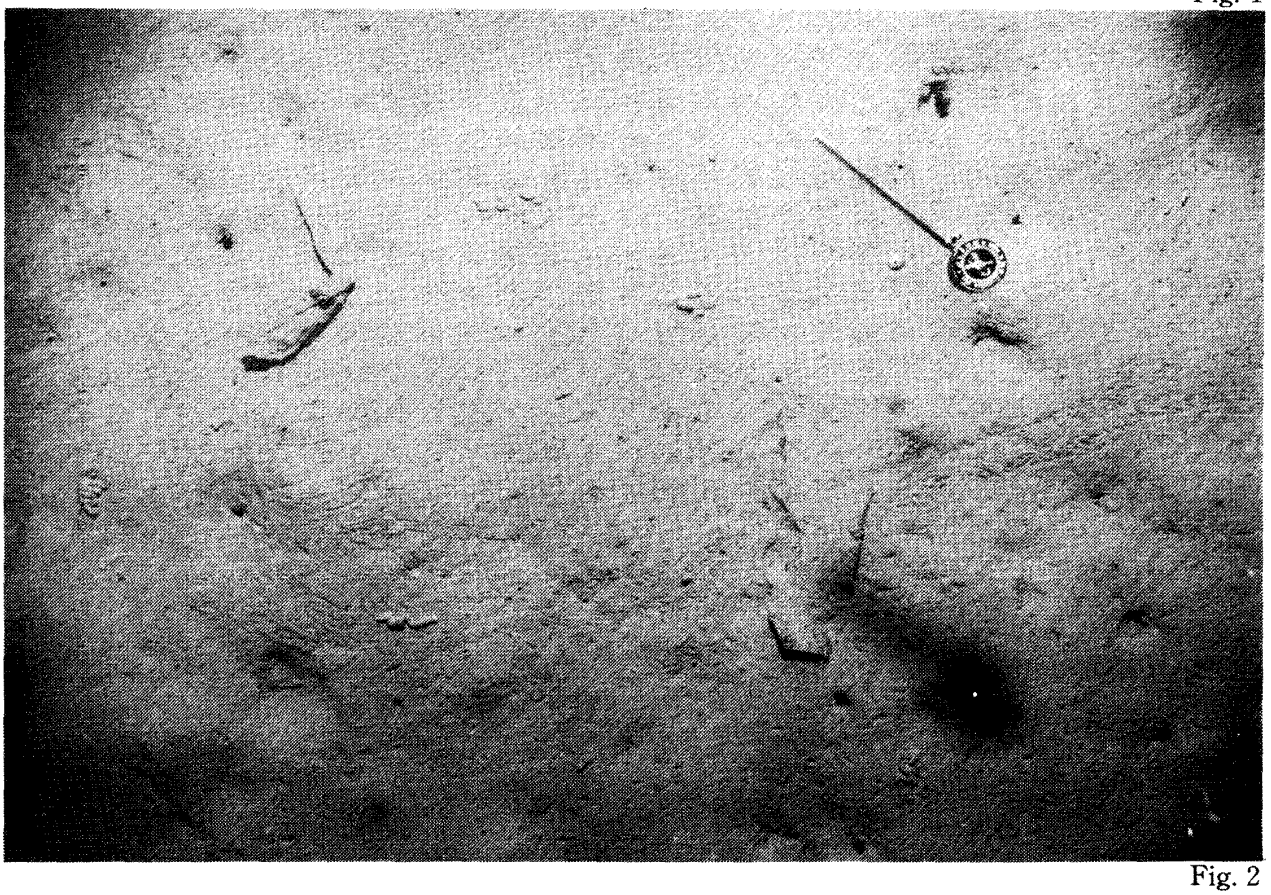

Fig. 2

Plate 11. Bottom photographs taken at Station 4, KT-77-7.

Fig. 1. A holothurian (*Enypniastes eximia* THEEL, 1882) and trails (scratching). Organisms responsible for the mounds and holes are not identified.
Water depth : 1418m, date : June 9, 1977, time : 13:24'55".
The vertical length of the photo spans a distance of 70.8 cm on the sea floor.

Fig. 2. A crab (*Paralomis multispina* BENEDICT, 1885) is producing foot prints in the upper right corner. Deep hollows may have been created by spatangoids (echinoderms).
Water depth : 1383m, date : June 9, 1977, time : 14:13'13".
The vertical length of the photo spans a distance of 79.8 cm on the sea floor.

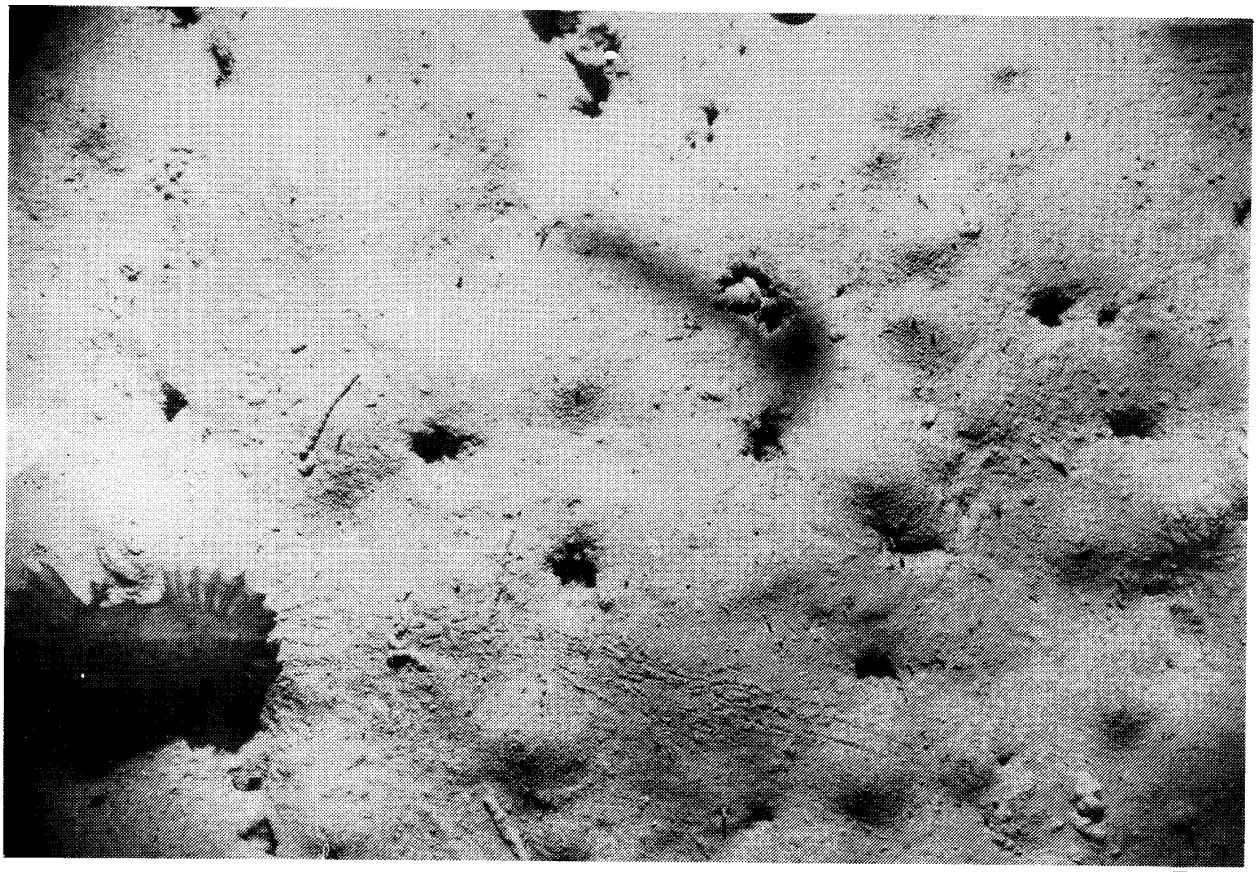

Fig. 1

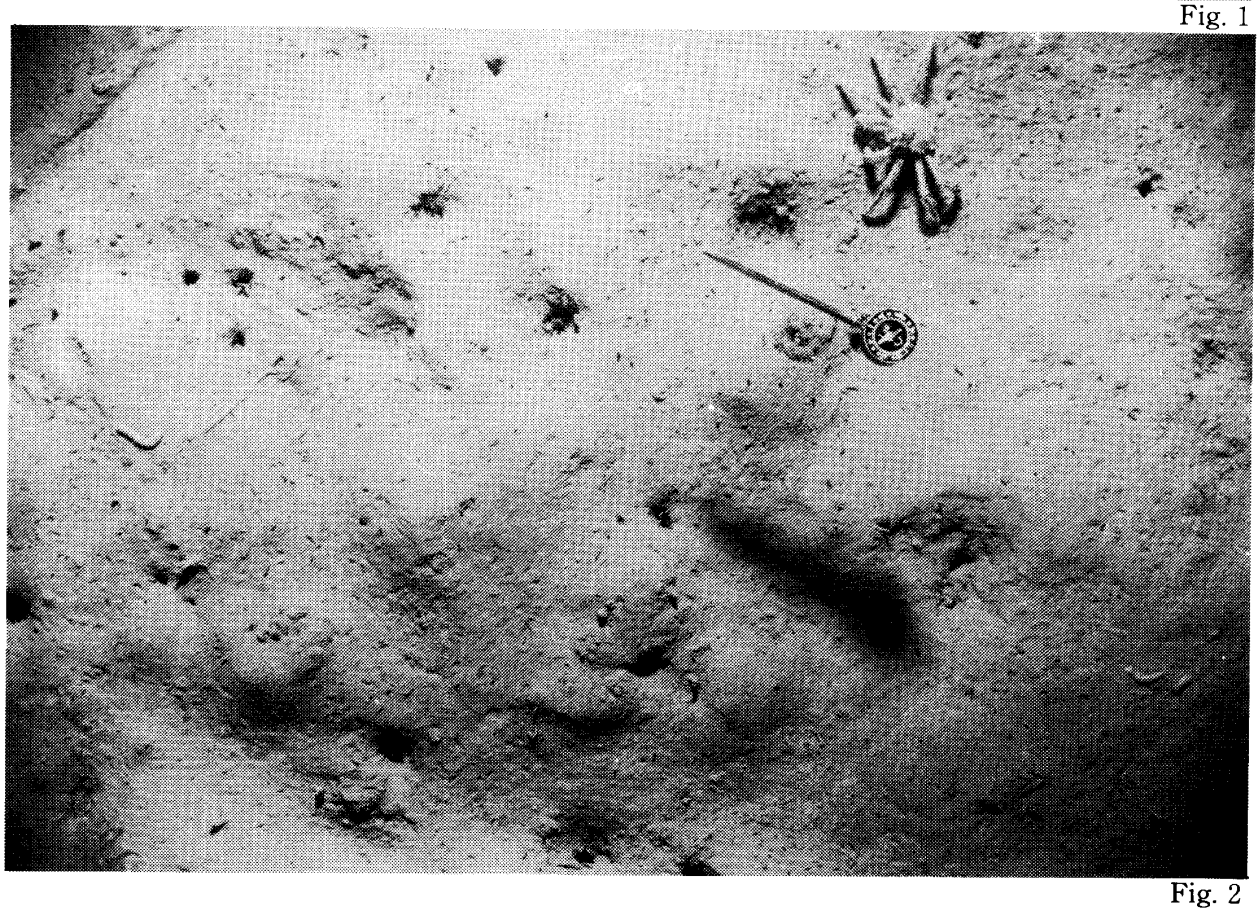

Fig. 2

Plate 12. Bottom photographs taken at Station 4, KT-77-7.

Fig. 1. Long straight faecal casts radiating from somewhat protruding tubes are produced by an organism of unknown origin.
Water depth : 1400m, date : June 9, 1977, time : 13:39'13".
The vertical length of the photo spans a distance of 45.4 cm on the sea floor.

Fig. 2. Annelid tubes scattered on the ground with numerous mounds and holes.
Water depth : 1402m, date : June 9, 1977, time : 13:35'07".
The vertical length of the photo spans a distance of 71.1 cm on the sea floor.

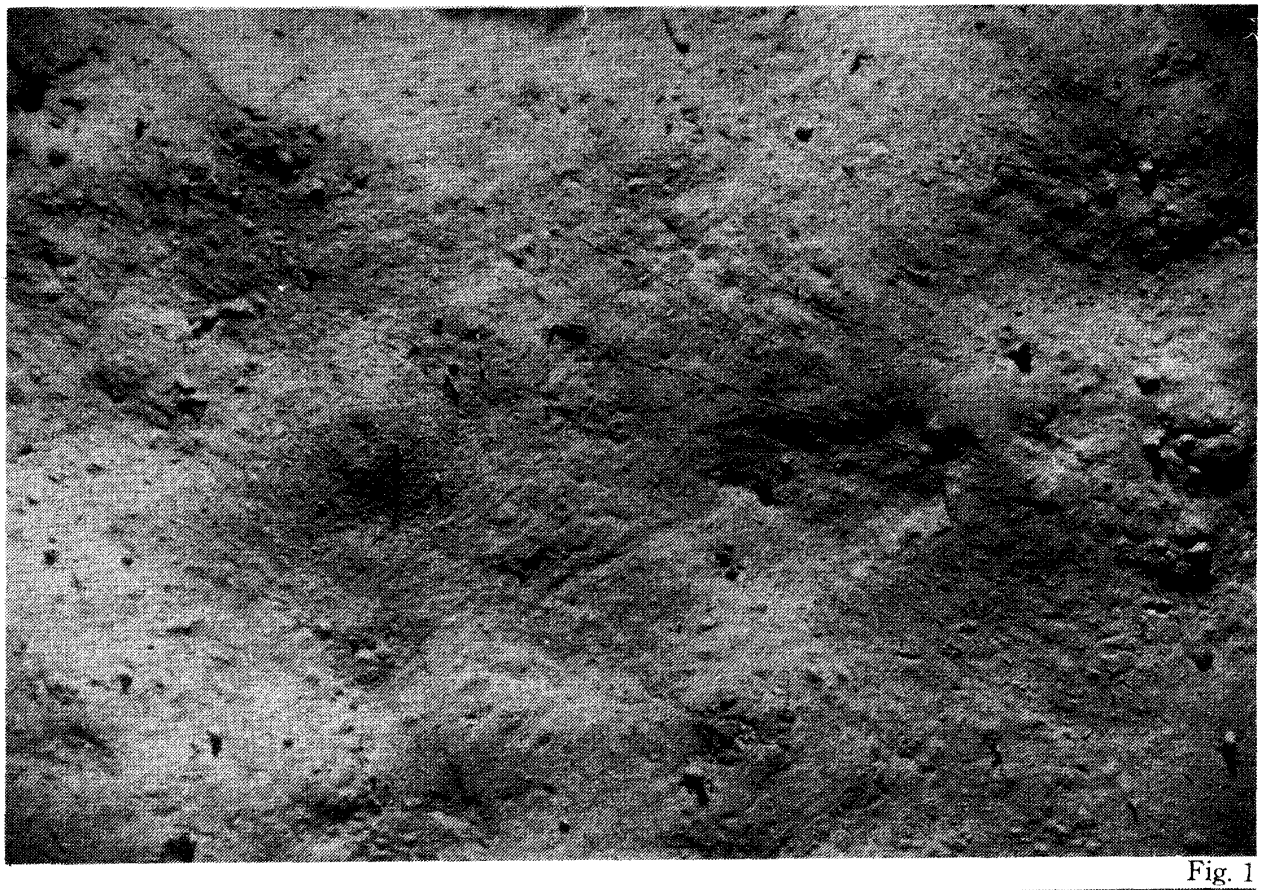

Fig. 1

Fig. 2

Plate 13. Bottom photographs taken at Station 4, KT-77-7.

Fig. 1. A brittle star (ophiuroids) created feather-like trails (S), which traverse the eroded trail of holothurian (H).
Water depth : 1422m, date : June 9, 1977, time : 13:18'43".
The vertical length of the photo spans a distance of 45.6 cm on the sea floor.

Fig. 2. Ripple marks produced by southward-flowing bottom currents.
Water depth : 1400m, date : June 9, 1977, time : 13:54'19".
The vertical length of the photo spans a distance of 132.6 cm on the sea floor.

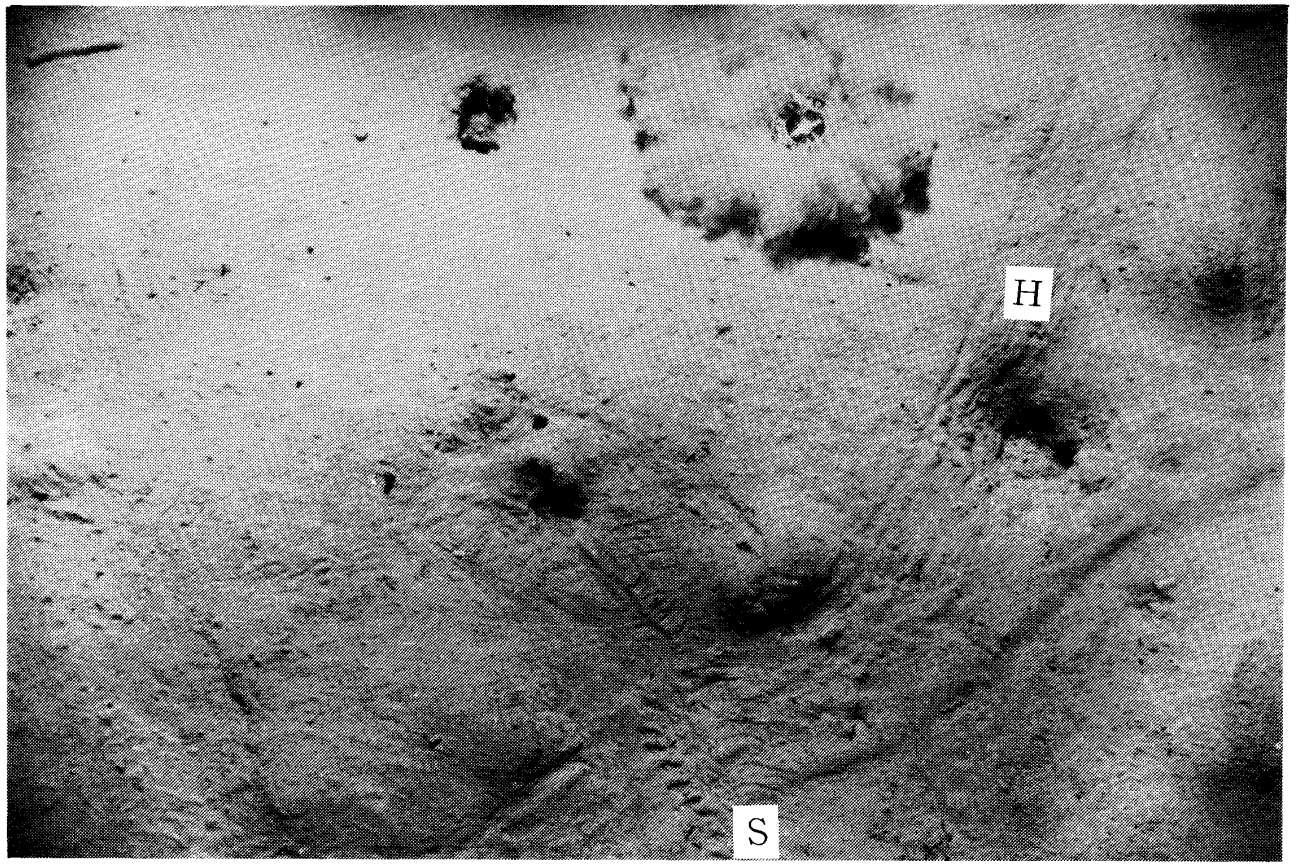

Fig. 1

Fig. 2

Plate 14. Bottom photographs taken at Station 4, KT-77-7.

Fig. 1. Faecal casts of holothurians and annelid (?) mounds.
Water depth : 1425m, date : June 9, 1977, time : 13:17'13".
The vertical length of the photo spans a distance of 46.8 cm on the sea floor.

Fig. 2. Mounds produced by annelids (?) are common. Organism responsible for the star-like marking is unknown.
Water depth : 1420m, date : June 9, 1977, time : 13:20'01".
The vertical length of the photo spans a distance of 60.4 cm on the sea floor.

Fig. 1

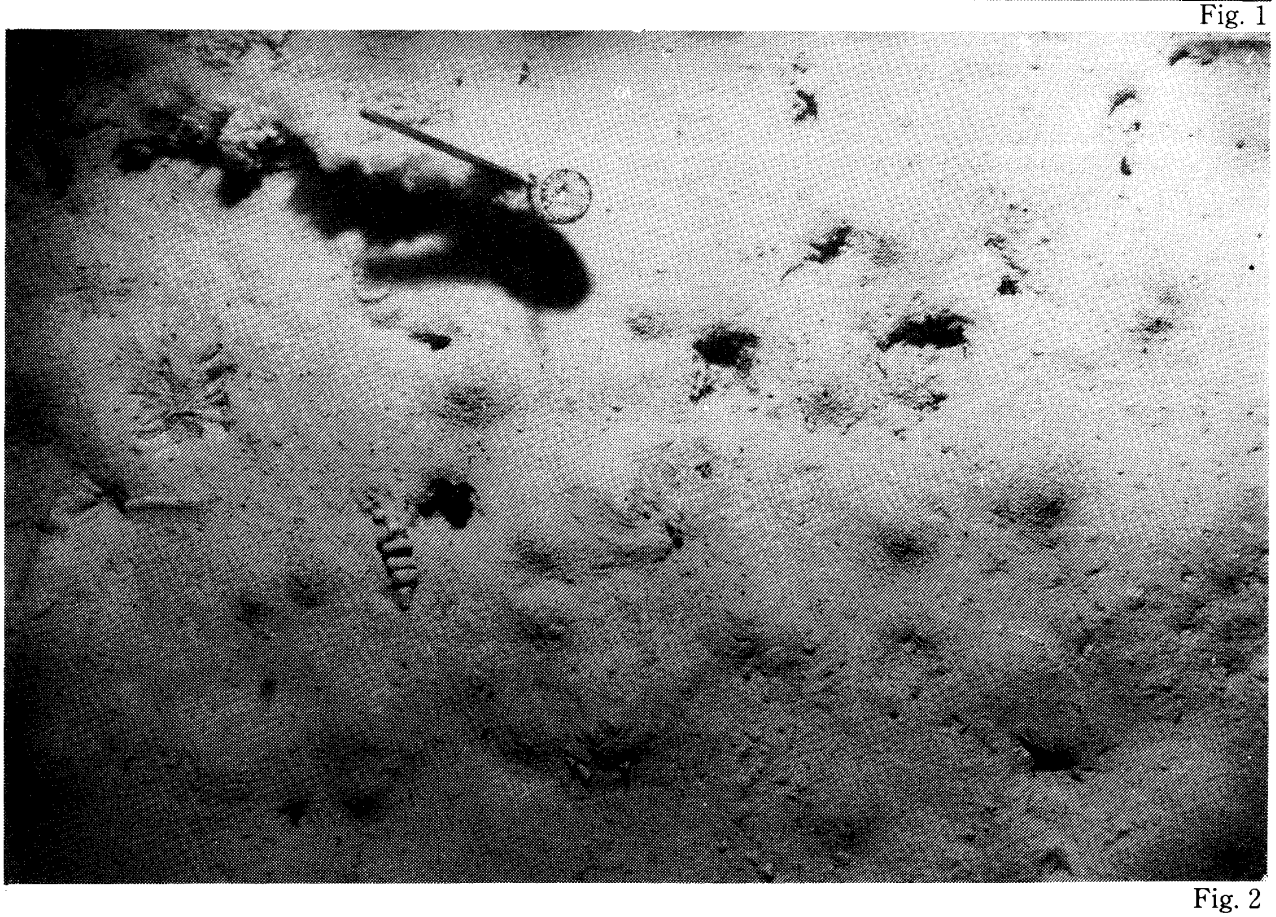

Fig. 2

Plate 15. Bottom photographs taken at Station T_1, KT-77-7.

Fig. 1. A spatangoid (*Lovenia gregalis*.ALCOCK, 1893) creeps under surface.
Water depth : 527m, date : June 10, 1977, time : 15:22'09".
The vertical length of the photo spans a distance of 105.6 cm on the sea floor.

Fig. 2. Holes produced by medium-sized spatangoids.
Water depth : 529m, date : June 10, 1977, time : 15:18'19".
The vertical length of the photo spans a distance of 69.1 cm on the sea floor.

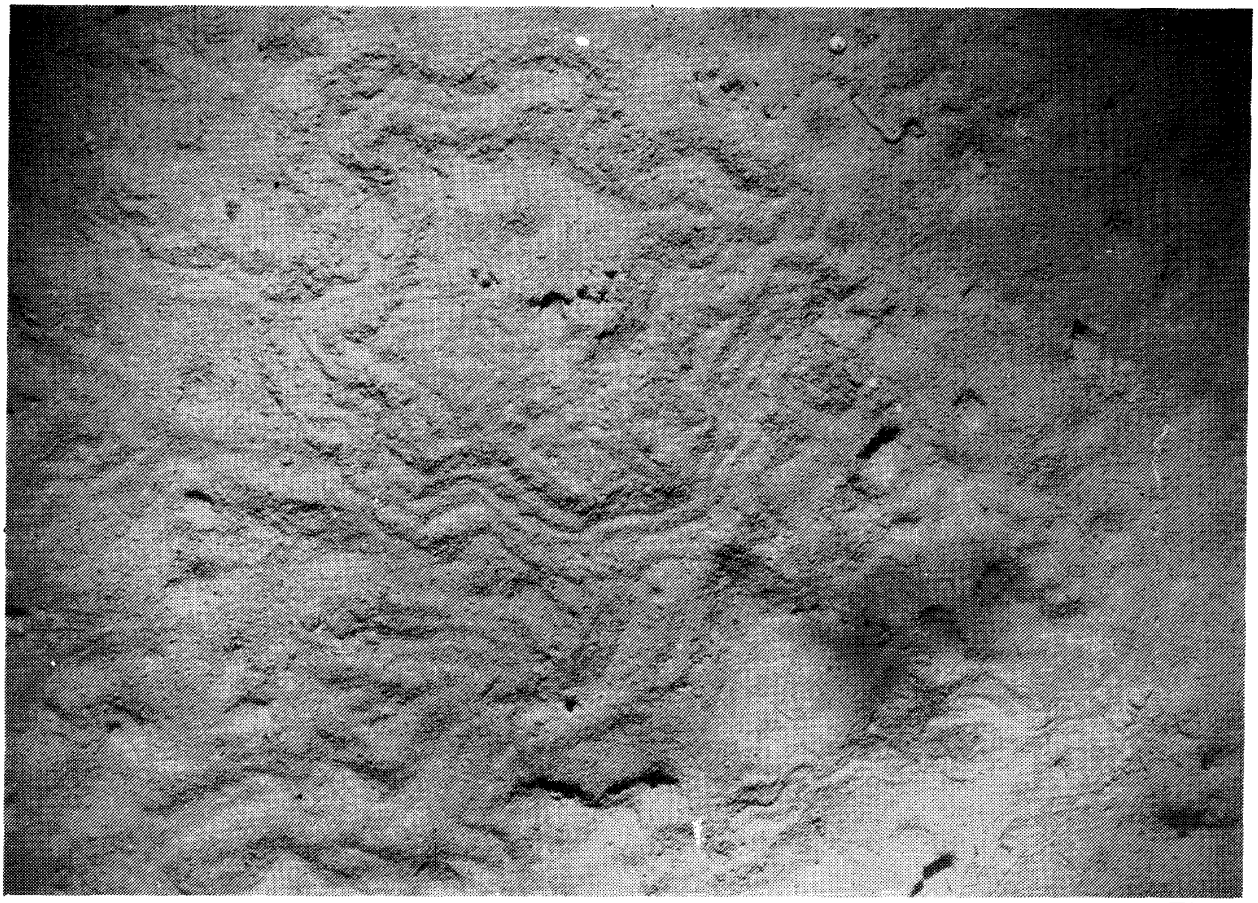

Fig. 1

Fig. 2

Plate 16. Bottom photographs taken at Station T_1, KT-77-7.

Fig. 1. Holes made by medium-sized spatangoids and arcs of small holes produced by unknown organisms.
Water depth : 536m, date : June 10, 1977, time : 15:11'03".
The vertical length of the photo spans a distance of 97.9 cm on the sea floor.

Fig. 2. Imprint tracks are foot prints of an echinothuriid sea-urchin, *Phormosoma bursarium* A. AGASSIZ, 1811. Arrow indicates an ophiuroid, *Ophiochitom fastigatus* LYMAN, 1878.
Water depth : 531m, date : June 10, 1977, time : 15:17'03".
The vertical length of the photo spans a distance of 69.5 cm on the sea floor.

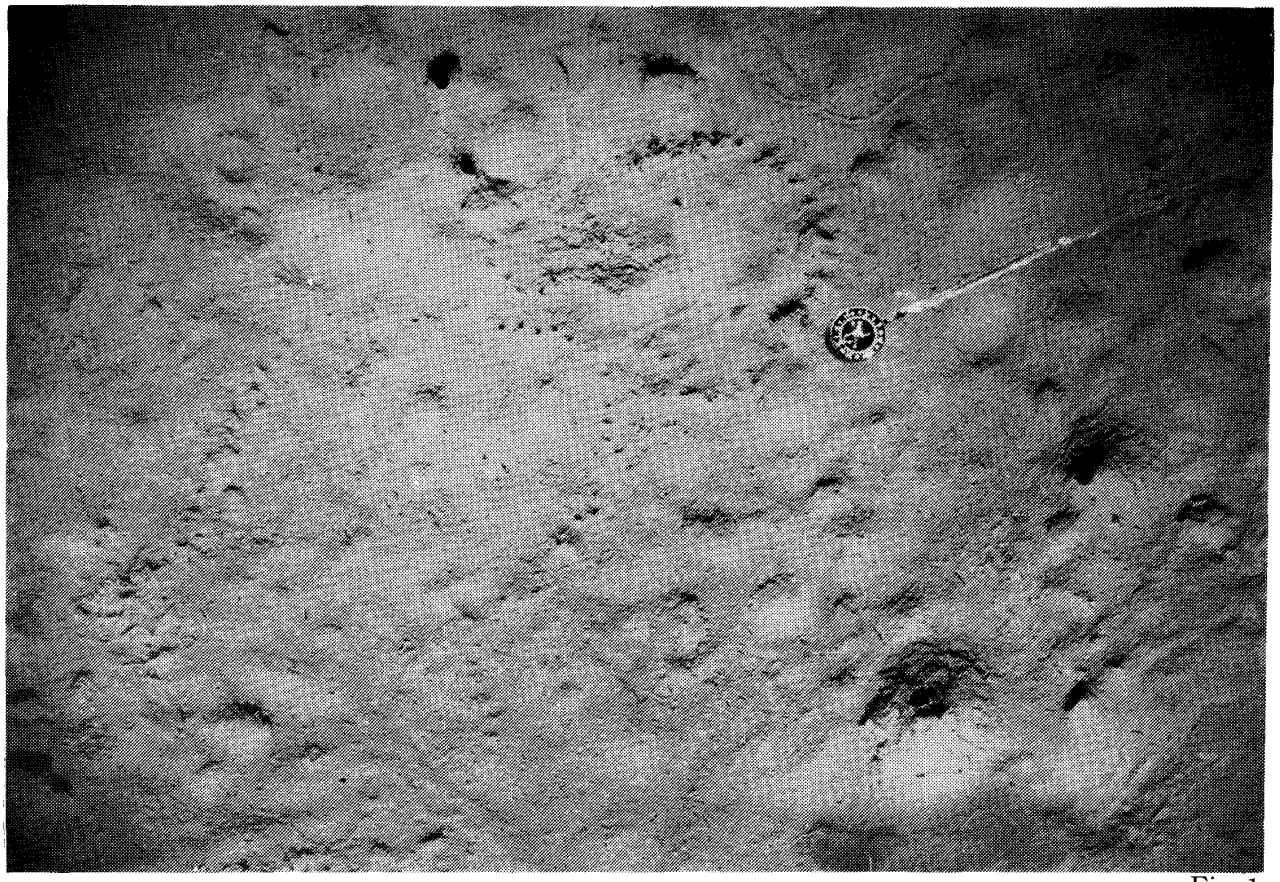

Fig. 1

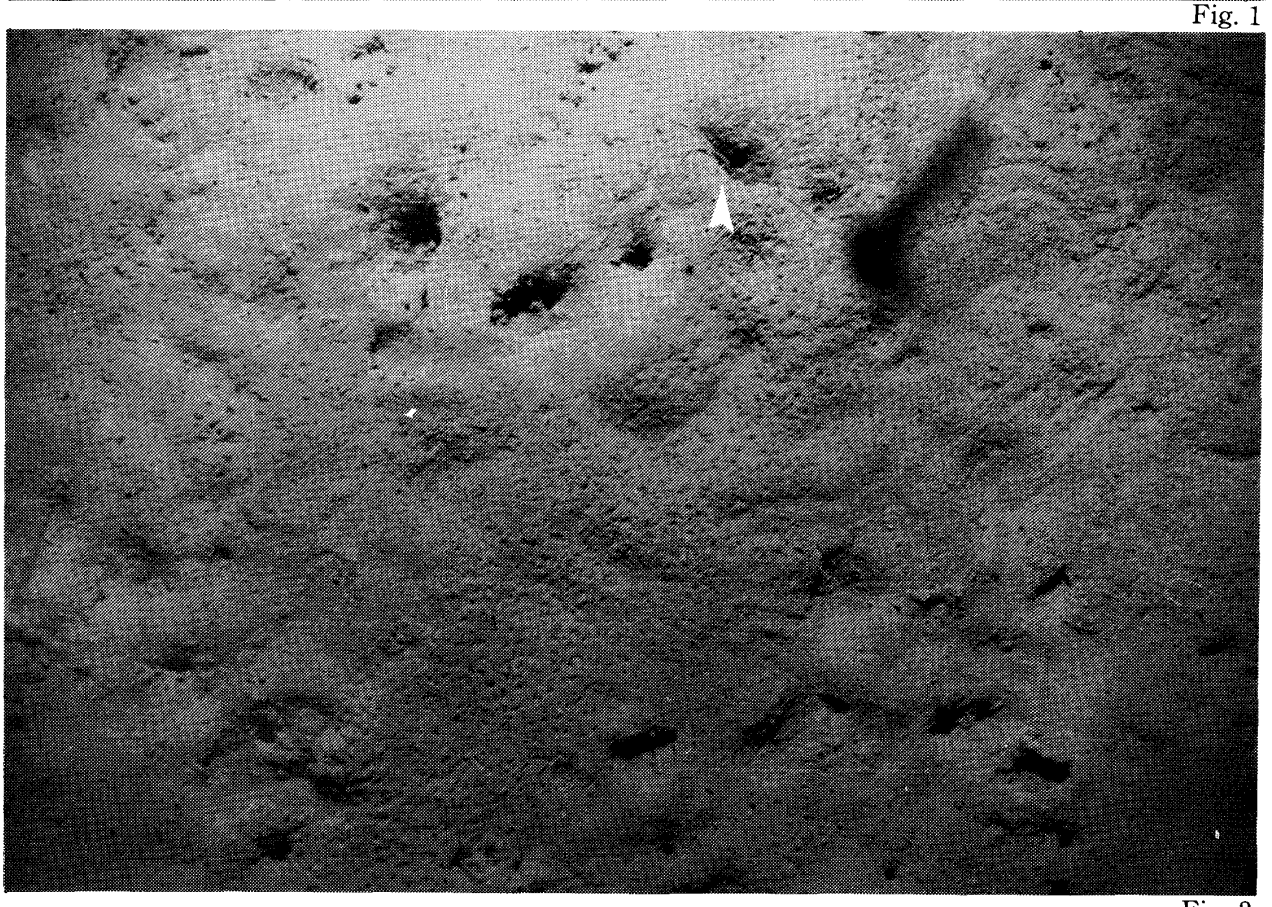

Fig. 2

Plate 17. Bottom photographs taken at Station T_1, KT-77-7.

Fig. 1. Lines of small holes are of unknown.origin. A large sea pen (*Pennatula naresi* KÖLLIKER, 1880) lies to the upper right. Two small sea pens are *Protoptilum orientale* NUTTING, 1912.
Water depth : 523m, date : June 10, 1977, time : 15:28′21″.
The vertical length of the photo spans a distance of 129.3 cm on the sea floor.

Fig. 2. A pile of coiled rope-like faeces produced by an unknown organism. A sea pen (*Protoptilum orientale* NUTTING, 1912) is indicated with an arrow.
Water depth : 510m, date : June 10, 1977, time : 15:46′39″.
The vertical length of the photo was not calculated.

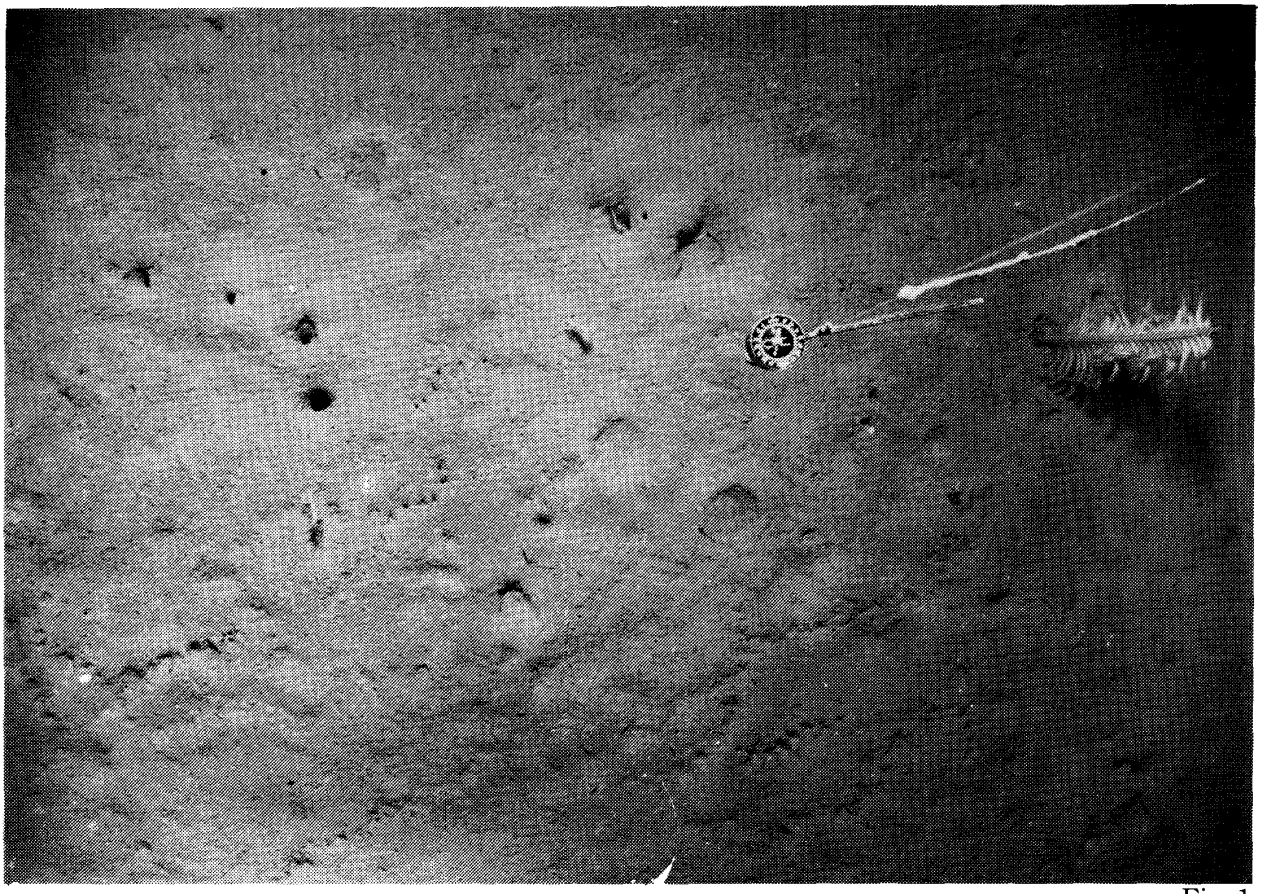

Fig. 1

Fig. 2

Plate 18. Bottom photographs taken at Station T_1, KT-77-7.

Fig. 1. Burrow openings produced by medium-sized spatangoids.
Water depth : 523m, date : June 10, 1977, time : 15:27'39".
The vertical length of the photo spans a distance of 58.4 cm on the sea floor.

Fig. 2. Vertical burrows of spatangoids and dotted imprint trails by *Phormosoma bursarium* A. AGASSIZ, 1881 (cf. Plate 16, Fig. 2).
Water depth : 511m, date : June 10, 1977, time : 15:45'27".
The vertical length of the photo spans a distance of 49.5 cm on the sea floor.

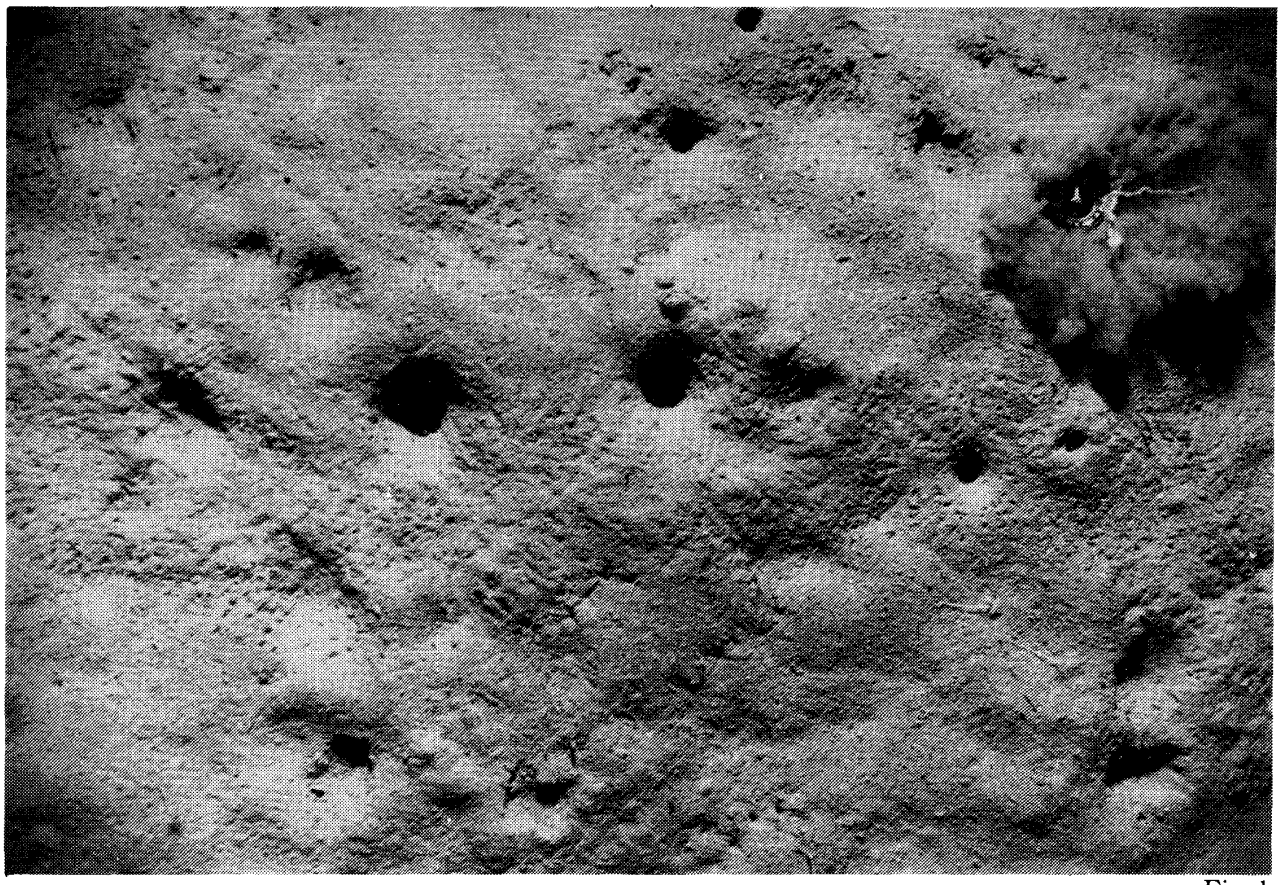

Fig. 1

Fig. 2

Plate 19. Bottom photographs taken at Station T_1, KT-77-7.

Fig. 1. Stellate grazing trace with central burrow thought to be produced by an echiuroid worm. Small sea pen (*protoptilum orientale* NUTTING, 1912) is seen in the lower right corner.
Water depth : 526m, date : June 10, 1977, time : 15:23′39″.
The vertical length of the photo spans a distance of 98.1 cm on the sea floor.

Fig. 2. Star-shaped trace (to the left) with a central hole, possibly a lebensspuren produced by an echiuroid worm (family Bonellidae). Radiating traces are grazing scrapes of the proboscis of the worm, which is situated in the central burrow. A sea pen (*Protoptilum orientale* NUTTING, 1912), vertical burrows of medium-sized spatangoids and a trail of a gastropod, probably *Ginebis argenteonitens* (LISCHKE, 1872) are seen.
Water depth : 513m, date : June 10, 1977, time : 15:43′33″.
The vertical length of the photo spans a distance of 96.7 cm on the sea floor.

Fig. 1

Fig. 2

Plate 20. Bottom photographs taken at Station T_1, KT-77-7.

Fig. 1. A simple coral, presumably *Fungiacyathus sibogae* (ALCOCK, 1902) producing circular depression. A soft-shelled sea-urchin responsible for the trail of pits (Pl. 16, fig. 2 ; Pl. 18, fig. 2) is seen in the center of the photo.

Water depth : 555m, date : June 10, 1977, time : 14:58'51".

The vertical length of the photo spans a distance of 190.0 cm on the sea floor.

Fig. 2. A typical burrow and feeding traces of an ophiuroid, *Ophiochiton fastigatus* LYMAN, 1878. This organism seems to scrape the mud surface and collect the detritus with its long arms. They often protrude 3 arms from the large opening of the burrow and one or two arms from smaller holes. G : Trail produced by a trochid gastropod, *Ginebis argenteonitens argenteonitens* (LISCHKE, 1872), g : deep trail, V-shaped in cross section produced by a small gastropod (?).

Water depth : 516m, date : June 10, 1977, time : 15:37'45".

The vertical length of the photo spans a distance of 89.9 cm on the sea floor.

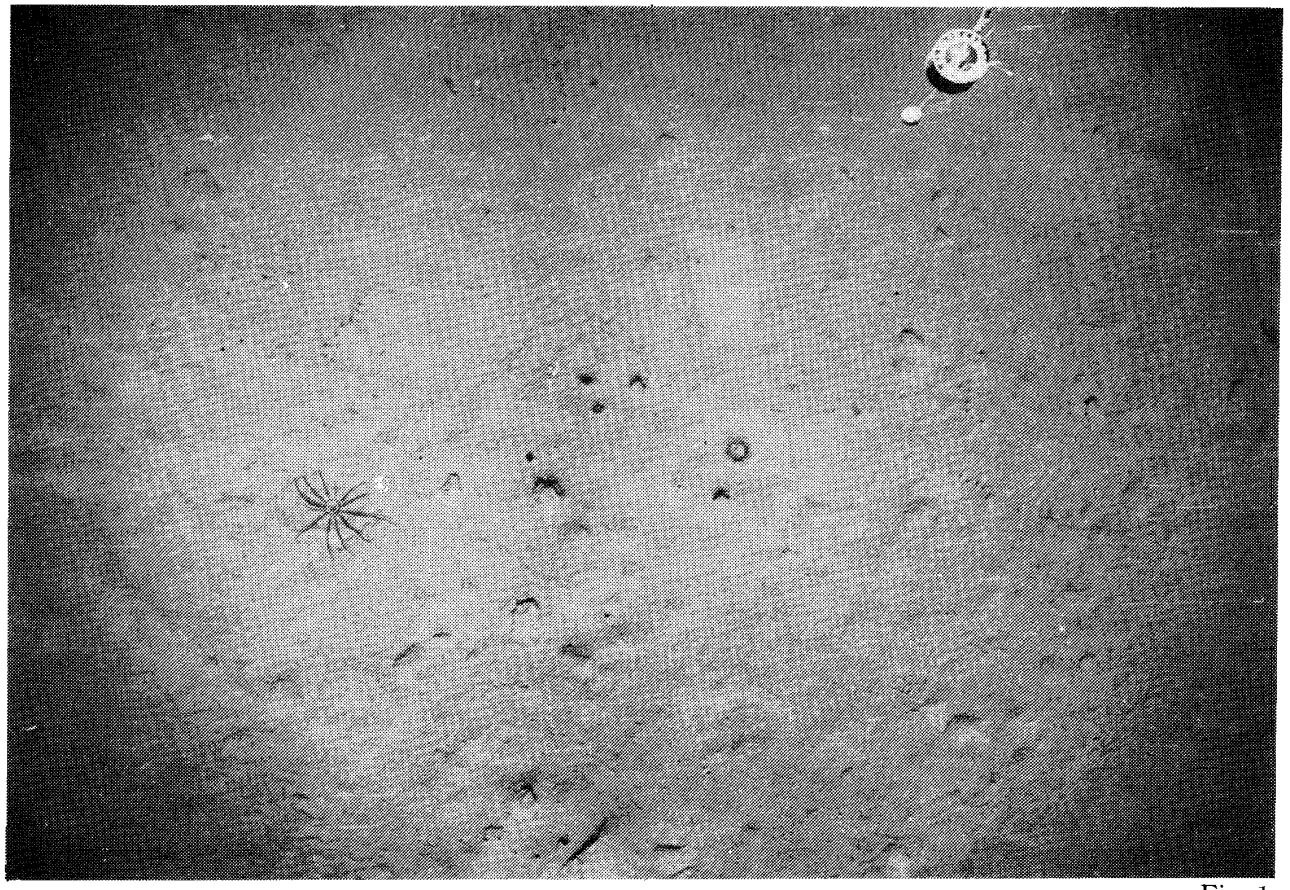

Fig. 1

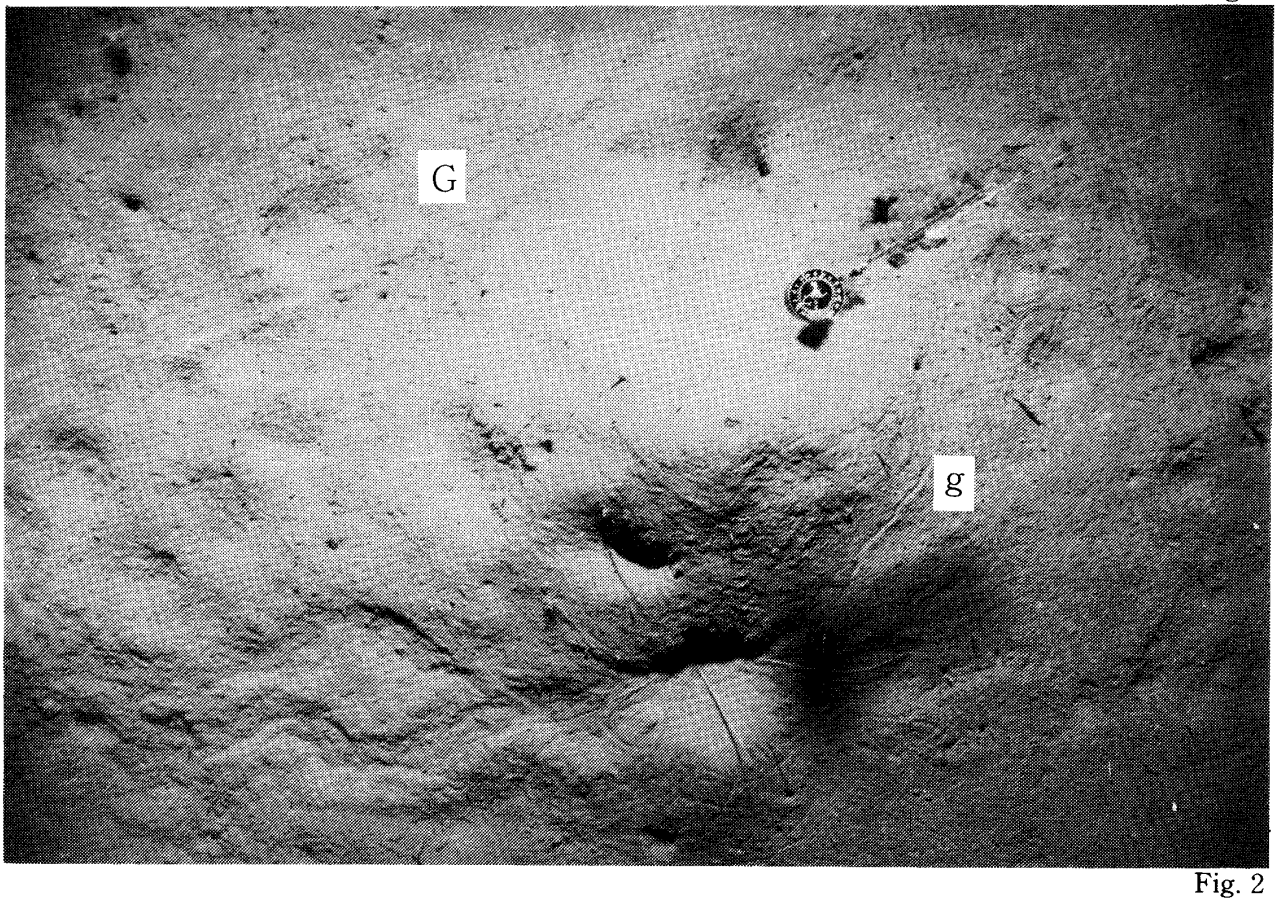

Fig. 2

Plate 21. Bottom photographs taken at Station T_1, KT-77-7.

Fig. 1. Trail of a gastropod, *Buccinum leucostoma* LISCHKE, 1872 and broad track of a spatangoid, *Lovenia gregalis* in the lower left. A : *Aphrodita aculeata* LINNAEUS, 1761.
Water depth : 556m, date : June 10, 1977, time : 14:57'45".
The vertical length of the photo spans a distance of 128.5 cm on the sea floor.

Fig. 2. S : star-shaped trace (see HÄNTZSCHELL, 1970).
Water depth : 516m, date : June 10, 1977, time : 15:37'57".
The vertical length of the photo spans a distance of 76.2 cm on the sea floor.

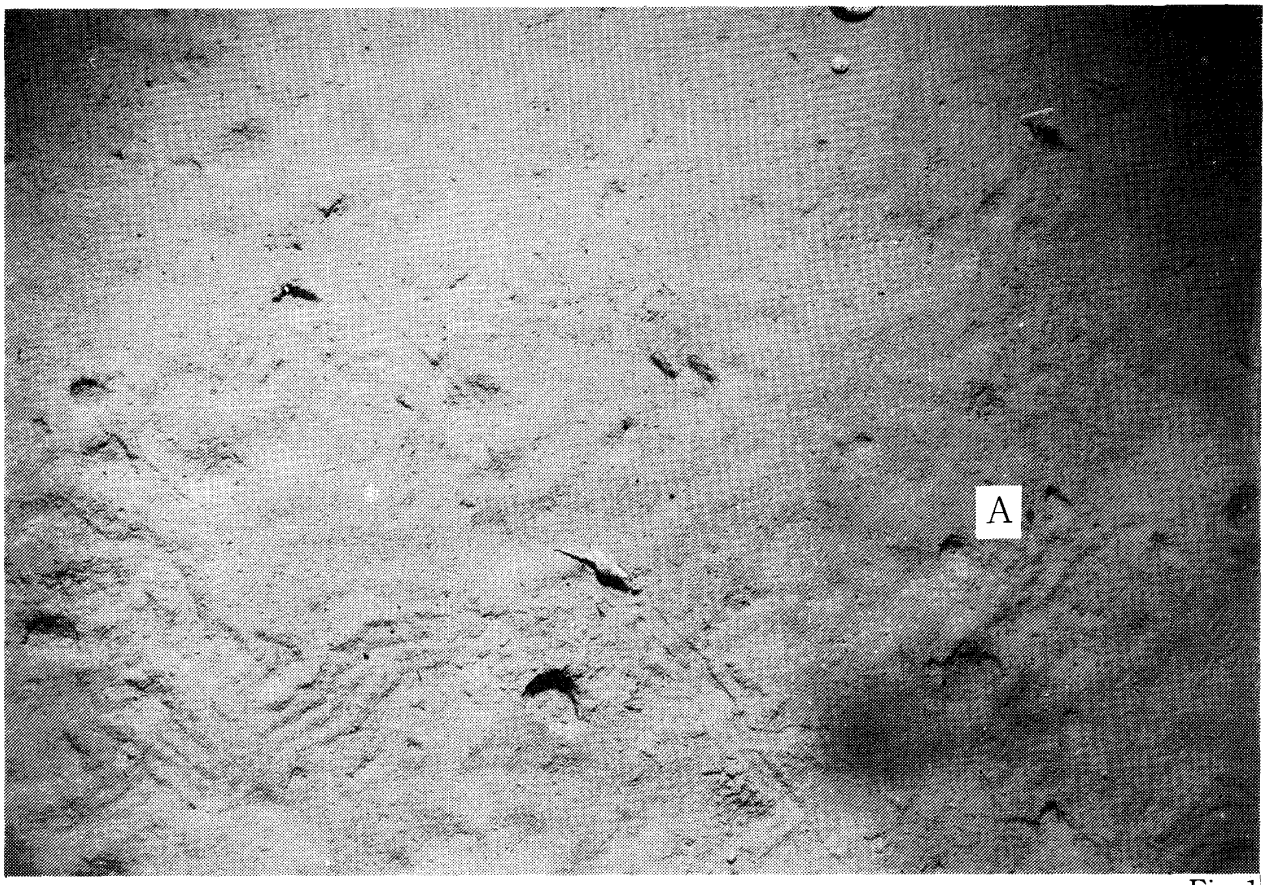

Fig. 1

Fig. 2

Plate 22. Bottom photographs taken at Station T_2, KT-77-7.

Fig. 1. Trail of a giant spatangoid, *Linopneustes fragilis* (DE MEIJERE, 1902). This bathyal species is a surface dweller, presenting a striking contrast to the shallow-water members, which are all burrowers.

Water depth : 684m, date : June 11, 1977, time : 10:44'28".

The vertical length of the photo spans a distance of 83.2 cm on the sea floor.

Fig. 2. Trail of a giant spatangoid, *Linopneustes fragilis* (DE MEIJERE, 1902). The trace consists of a median and lateral ridges, and oblique shallow grooves. Note the evidence of frequent crossings and encounters.

Water depth : 653m, date : June 11, 1977, time : 10:56'10".

The vertical length of the photo spans a distance of 98.1 cm on the sea floor.

Fig. 1

Fig. 2

Plate 23. Bottom photographs taken at Station T_2, KT-77-7.

Fig. 1. Close-up of the tracks made by a giant spatangoid, *Linopneustes fragilis* (DE MEIJERE, 1902).
Water depth : 685m, date : June 11, 1977, time : 10:31'22".
The vertical length of the photo spans a distance of 51.7 cm on the sea floor.

Fig. 2. Trails probably created by a trochid gastropod, *Bathybembix aeora* (WATSON, 1879).
Water depth : 685m, date : June 11, 1977, time : 10:28'34".
The vertical length of the photo spans a distance of 83.8 cm on the sea floor.

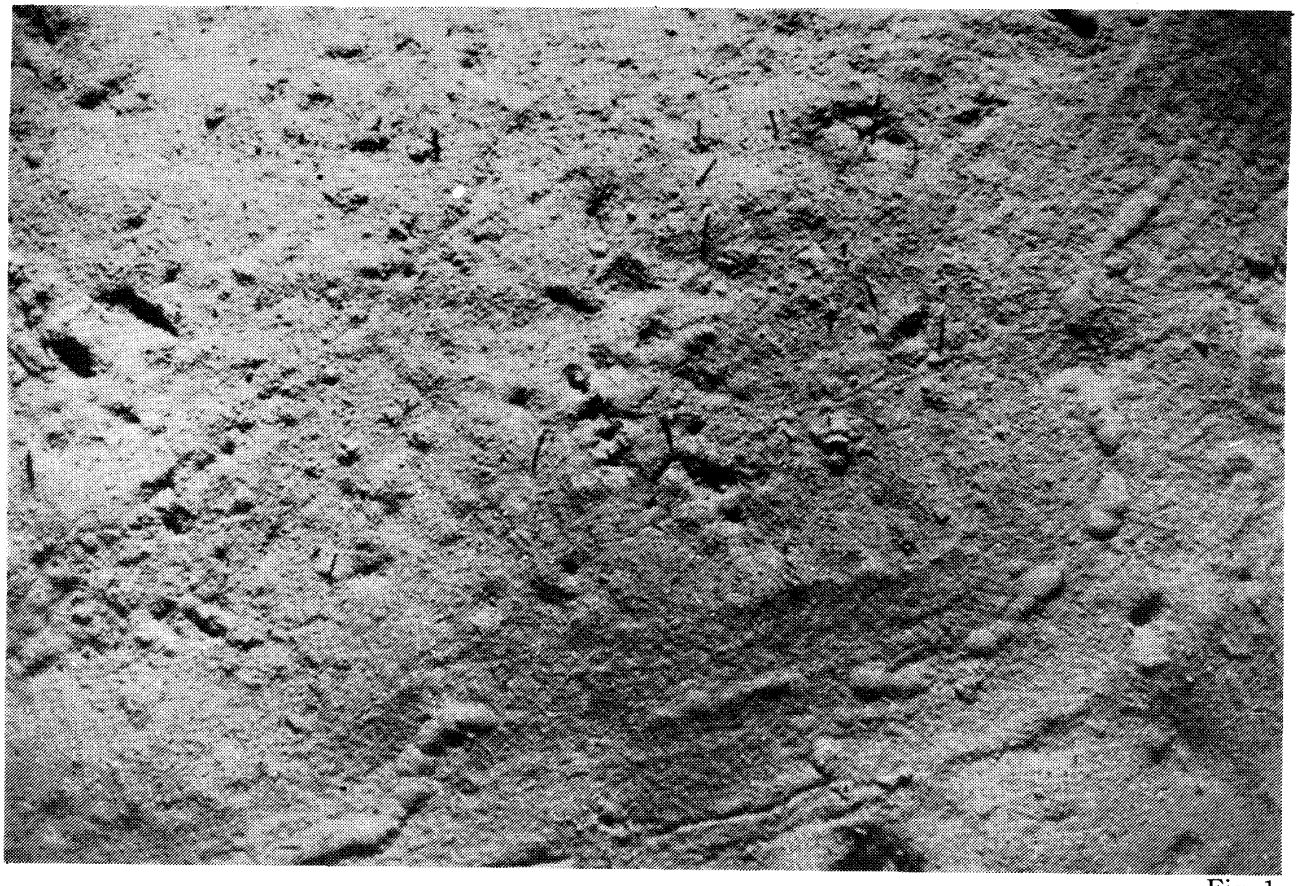

Fig. 1

Fig. 2

Plate 24. Bottom photographs taken at Station T_2, KT-77-7.

Fig. 1. S : track and faecal cast of a synallactid holothurian, *Synallactes multivesiculatus* OHSHIMA, 1915, L : track of *Linopneustes fragilis*, B : test of dead spatangoid, *Brisaster owstoni* MORIENSEN, 1950. P : rounded cobble, around which current scour is seen.
Water depth : 685m, date : June 11, 1977, time : 10:28′28″.
The vertical length of the photo spans a distance of 80.3 cm on the sea floor.

Fig. 2. Characteristic foot prints and faecal casts of a holothurian, *Enypniastes eximia* THEEL, 1882, which is capable of active swimming movements.
Water depth : 650m, date : June 11, 1977, time : 11:04′10″.
The vertical length of the photo spans a distance of 97.7 cm on the sea floor.

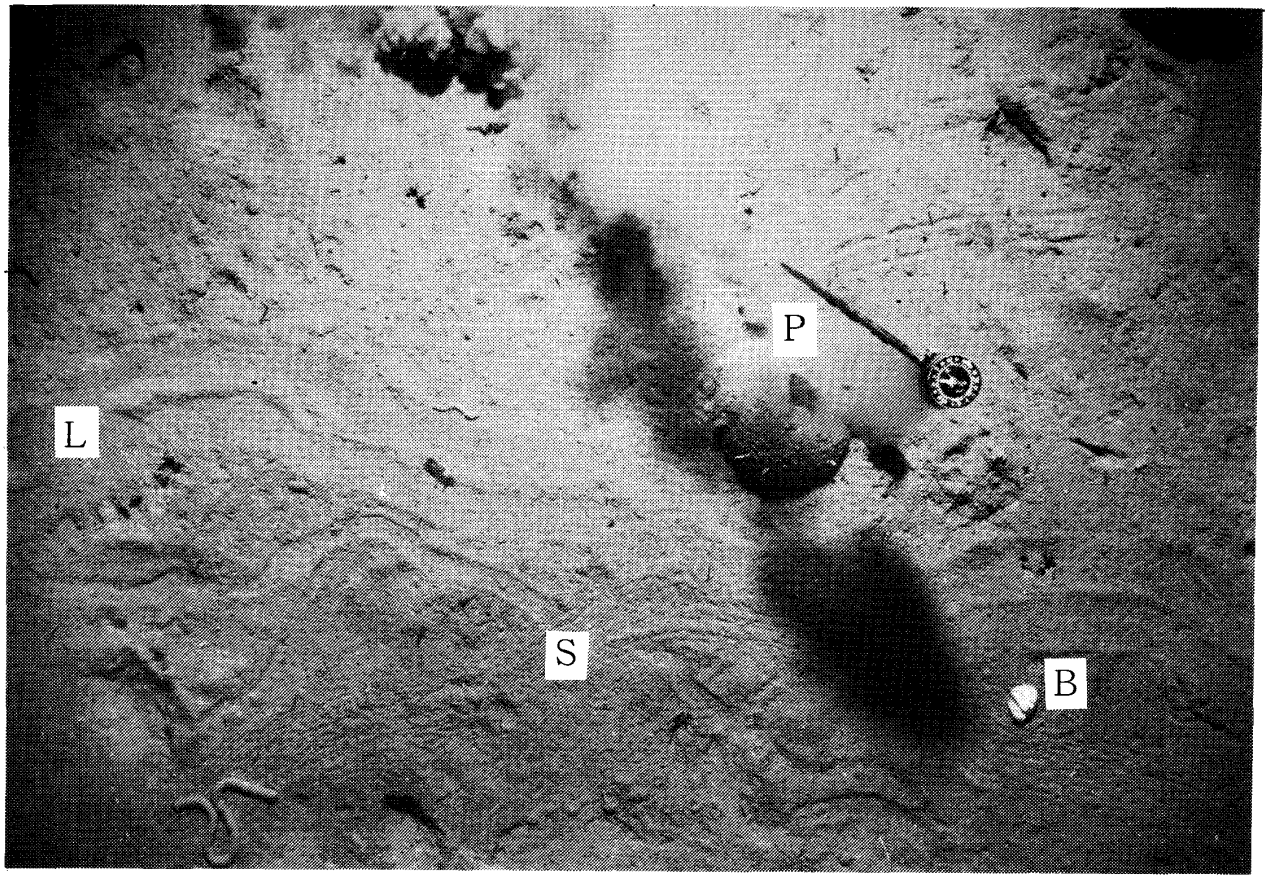

Fig. 1

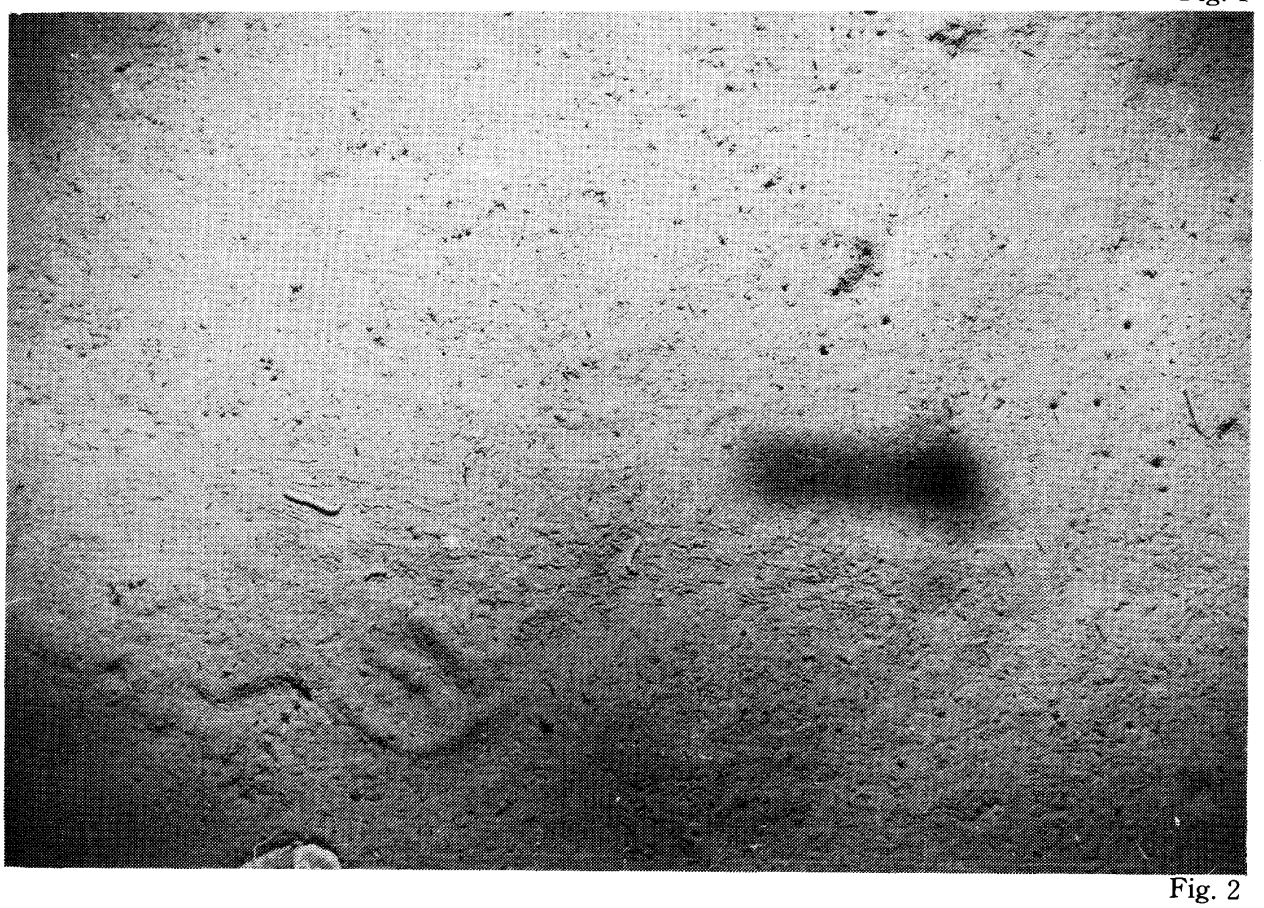

Fig. 2

Plate 25. Bottom photographs taken at Station T_2, TK-77-7.

Fig. 1. A resting trace produced by a slender-armed asteroid, *Zoroaster ophiactis* FISHER, 1916.
Water depth : 649m, date : June 11, 1977, time : 11:05′22″.
The vertical length of the photo spans a distance of 125.8 cm on the sea floor.

Fig. 2. Sinuous trail produced by a trochid gastropod, *Bathybembix aeora* (WATSON, 1879). The maker of the peculiar scoop-like depression cannot be determined, but it might be some benthic shrimp.
Water depth : 685m, date : June 11, 1977, time : 10:26′40″.
The vertical length of the photo spans a distance of 93.0 cm on the sea floor.

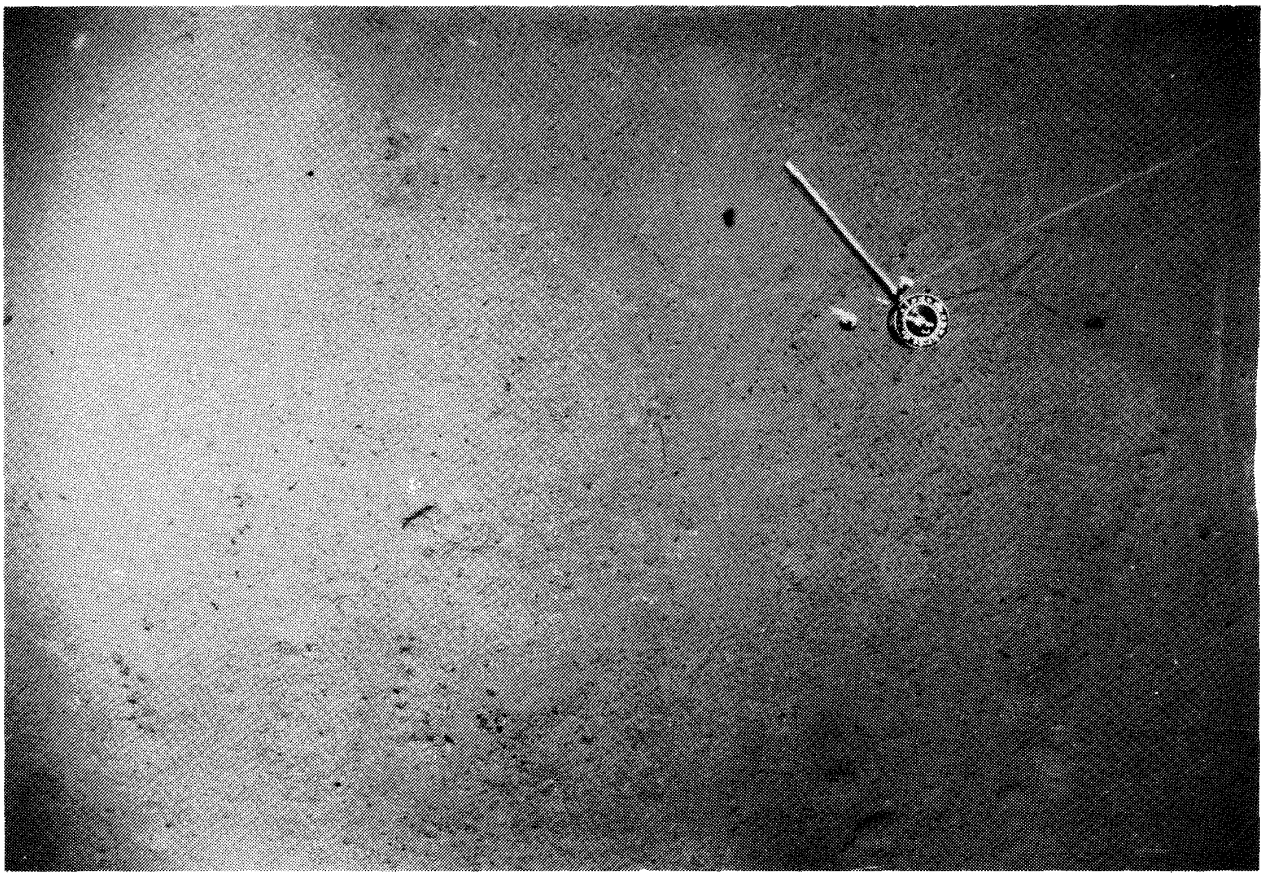

Fig. 1

Fig. 2

Plate 26. Bottom photographs taken at Station T_2, TK-77-7.

Fig. 1. Track of *Linopneustes fragilis* and a faecal cast in a spiral-shaped pile. The animal responsible for this faecal pile is unknown. A : cerianthid anemone.
Water depth : 654m, date : June 11, 1977, time : 10:54′04″.
The vertical length of the photo spans a distance of 98.5 cm on the sea floor.

Fig. 2. Coiled faecal string. The maker of this faecal pile is unknown.
Water depth : 685m, date : June 11, 1977, time : 10:32′22″.
The vertical length of the photo spans a distance of 78.8 cm on the sea floor.

Fig. 1

Fig. 2

Plate 27. Bottom photographs taken at Station T_2, TK-77-7.

Fig. 1. Fan-shaped pile of faeces casted from the central hole, which is a dwelling structure of an unknown organism. g: a scaphopod, *Godila sagamiensis* KURODA and HABE, 1971 leaves a narrow, deep furrow on the track of a giant spatangoid.

Water depth : 684m, date : June 11, 1977, time : 10:44'10".

The vertical length of the photo spans a distance of 66.2 cm on the sea floor.

Fig. 2. Fan-shaped pile of faecal casts. The organism which produced this faecal pile is unknown. S : a shrimp, *Sclerocrangon* sp. digs a shallow depression and leaves radial impressions of its antennae.

Water depth : 654m, date : June 11, 1977, time : 10:53'22".

The vertical length of the photo spans a distance of 70.8 cm on the sea floor.

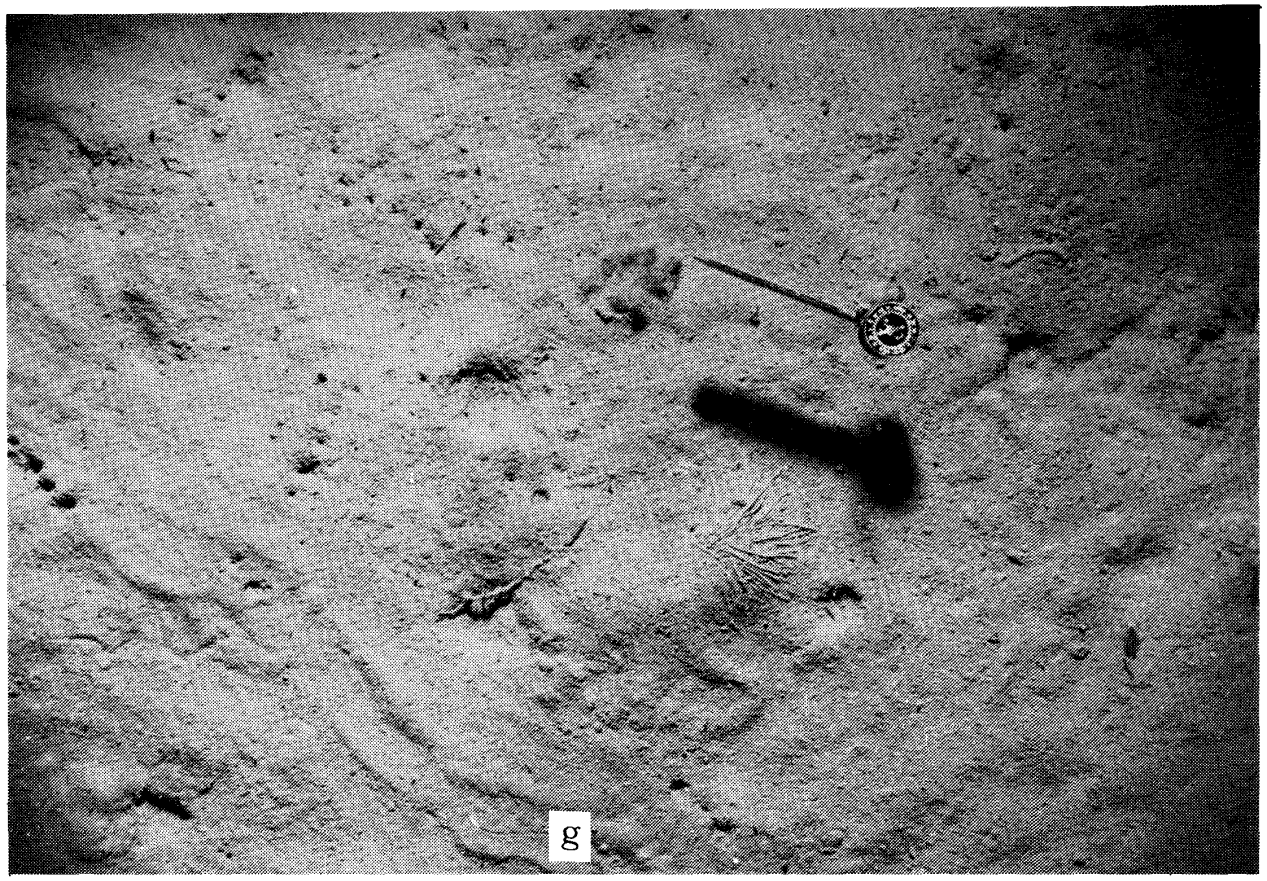

Fig. 1

Fig. 2

Plate 28. Bottom photographs taken at Station T_2, TK-77-7.

Fig. 1. Star-shaped impression : a resting trace (cubichnia) produced by slender-armed asteroid, *Zoroaster ophiactis* FISHER, 1916.
Water depth : 650m, date : June 11, 1977, time : 11:04'34".
The vertical length of the photo spans a distance of 84.4cm on the sea floor.

Fig. 2. The long thread-like structure projecting from a small hole may be an extended proboscis of an echiuroid worm (Bonellidae) scraping the mud surface. B : a trochid gastropod, *Bathybembix aeora* (WATSON, 1879).
Water depth : 653m, date : June 11, 1977, time : 11:00'34".
The vertical length of the photo spans a distance of 169.7cm on the sea floor.

Fig. 1

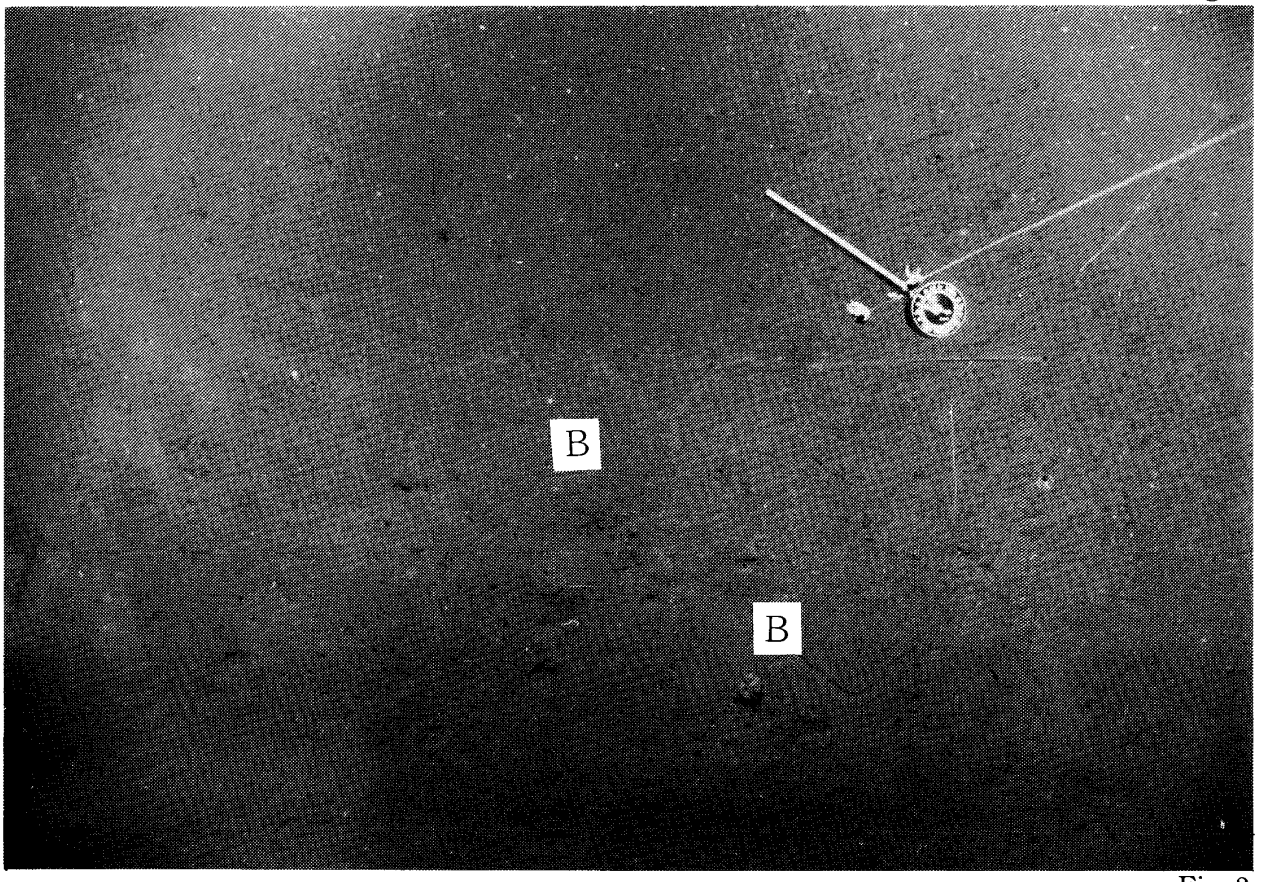

Fig. 2

Plate 29. Bottom photographs taken at Station T_1, KT-77-7.

Fig. 1. A spatangoid (*Lovenia gregalis* ALCOCK, 1893) creeps under the surface, taking rest at some places (arrows) (cf. Plate 15, Fig. 1). P : *Peniagone japonica* OHSHIMA, 1915.
Water depth : 580m, date : June 10, 1977, time : 14:49'21".
The vertical length of the photo spans a distance of 104.8cm on the sea floor.

Fig. 2. A trail of *Ginebis argenteonitens argenteonitens* (LISCHKE, 1872) (G in the bottom). p: *Protoptilum orientalis* NUTTING, 1912.
Water depth : 519m, date : June 10, 1977, time : 15:33'03".
The vertical length of the photo spans a distance of 110.9cm on the sea floor.

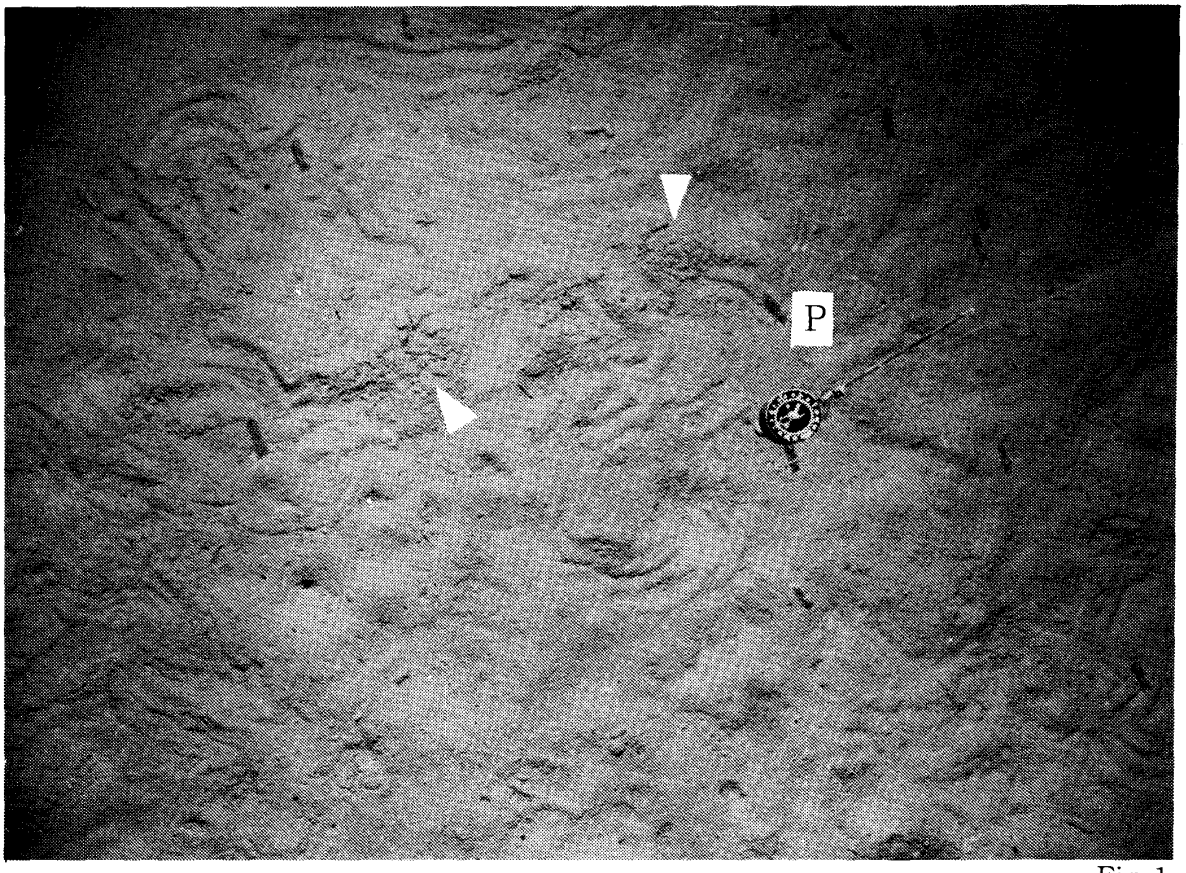

Fig. 1

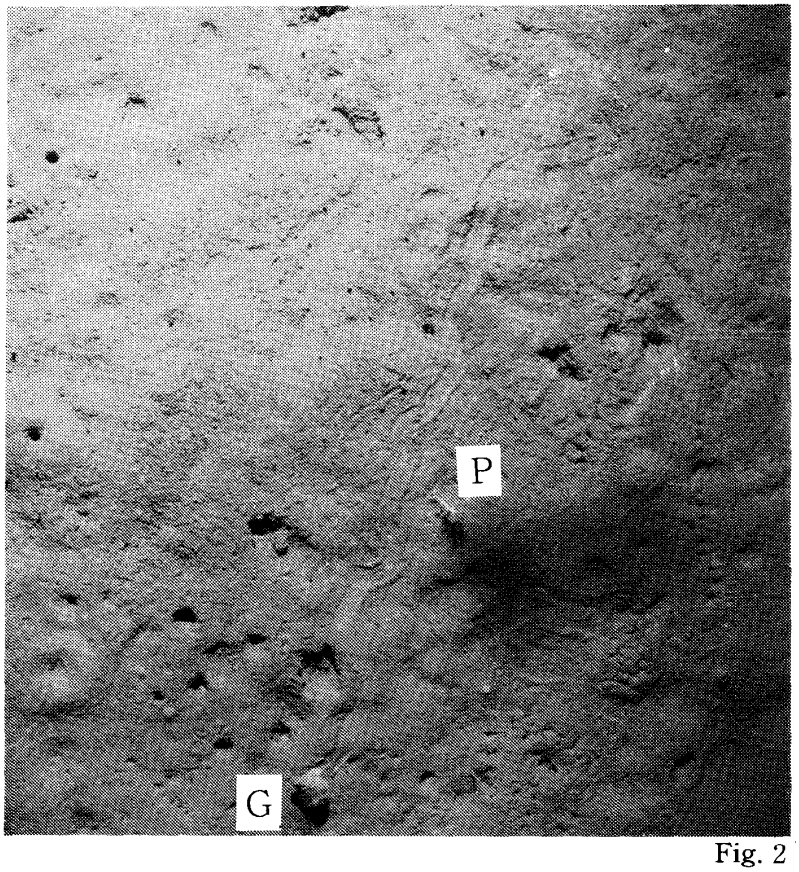

Fig. 2