調査と研究④

北西九州、呼子北方と壱岐南東の海底断層

Faults on the Seabeds SE of Iki and N of Yobuko, NW-Kyushu, Japan

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概　要

これは，国際ハイウェイ構想・日韓トンネル予定ルートにおける小規模断層の存在を推定するための最初のこころみである．

海底トンネルの多くの場合，ルート上の断層を発見することが必然的に非常に重要となる．それは，2,043.5km の音響映像（ウォーターガン，マルチチャンネル，単プロセッシング）から導き出し，同時に得られた反射波から海底地形図も作成した．壱岐東方は，539.6kmが測定された(Fig. 2)．呼子の北方では，1,503.9km であり(Fig. 3)，重複した部分もあった (Fig. 1)．測線図の網は壱岐南東方では1,000m×3,000m，呼子北方は400m×1,000m，ところによっては400m メッシュの部分もある (Fig. 2 と 3 の細い線参照)．

海底の音波探査としては，比較的粗い網だった．よって，そこからの情報は限定されたものでしかなく，図面を描くにも，どれも不十分な仮説でしかない．

結論として以下に示す．

……壱岐南東方には，比較的小規模な地溝が存在し，その地溝の北東側は，鎖状にある小さい火山島として確認できる．

……呼子の北西から北方向には 2 つの凹地溝造がある．

……次のような小規模地域が存在する(Fig. 4)．場所によってはその中に断層の方向が視認できる．それらは，北西から南東(325－135°, Fig 5)，北北東から南南西(022.5－202.5°)，東北東もしくは東から西南西もしくは西 (067.5-090－247.5-270°)，北北西もしくは北から南南東もしくは南 (337.5-000－157.5-180°)方向であり，外にも方向が確認できるのと同じほど明確である．

Resumen

This is the first attempt to deduce the existence of smaller faults on the probable route of the Japan - Korea- Tunnel of the International Highway Project. As most of the tunnel will be under the sea, it is naturally of great importance to be able to locate faults along the route. The derivation was made

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from 2,043.5 km of sonic profiles (taken by watergun and multi-channel, simple processing) in conjunction with the topographic seafloor map established from simultaneously taken echo-soundings. East of Iki-island 539.6 km (Fig. 2) have been recorded and N of Yobuko 1,503.9 km (Fig.3), with a slight overlap(Fig. 1). The profile-net was in the case of SE of Iki 1 × 3 km, whereas N of Yobuko the rectangle was 400×1,000 m, and in some places a 400 m square (comp. thin lines in Fig. 2 & 3).

The sonic survey of the seabed had a rather wide mesh. This is naturally still a very limited information base, so any conclusions drawn from this data-base have to be incomplete and can only be tentative.

The results indicate so far :

— a smaller old graben is approaching Iki from the SE; the northeastern side of the graben is marked with a chain of small volcanic islands.

— NW to N of Yobuko two older depression structures.

— the presence of smaller areas (comp. Fig. 4) in which faults of certain directions are a bit more often visible. The regional NW — SE (325 — 135°, (comp. Fig. 5)), NNE — SSW (022.5 — 202.5°),

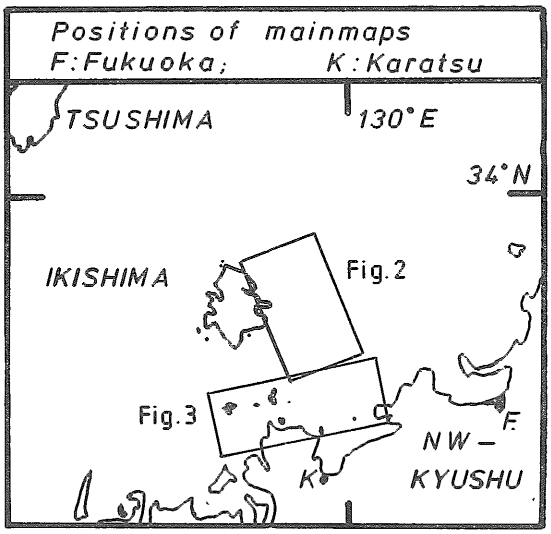


Fig.1. : Location of the areas investigated :
Fig.2 = SE of Ikishima; Fig.3 = N of Yobuko.

ENE-E—WSW-W (067.5- 090 — 247.5 -270°), NNW-N—SSE-S (337.5—000—157.5-180°) trends as well as some other directions are present (comp. Fig. 2 & 3).

INTRODUCTION

For the construction of a tunnel between Korea and Japan (about 250km), as part of the International Highway Project, it is important to locate faults along the route, as most of the tunnel will be under the sea. More than 15,000km of sonic profiles (sparker, watergun) have been recorded so far in order to asses the problems posed by geological factors and to find the most probable route for the tunnel or the best places for bridge foundations as an alternative solution for parts closer to the main land of Korea or the island of Kyushu.

The two maps presented, 1:120,000, are both from the southern part of the route, as there construction is most likely to start earlier than in the other parts, and more detailed information is needed more urgently.

METHOD:

The equipment used for recording the sonic profiles was:

Watergun: 6.3—12.6 l (400-800inch^3); streamer: nearest offset 160m, 12-channels at 3 m depth, at 20m spacing; recording: on DMS 1200 tapes. The position of the shot-points was monitored with Trisponder navigation system.

The simple processed profiles were used to asses the validity of linear elements, which were derived from the topographic map of the seafloor using the principles of aerial photo interpretation. The topographic seafloor map was established in 1:25,000 from the echo-soundings (taken at the same time as the sonic profiles). The depth accuracy of that map is estimated to be +— 1.5m along the profiles and +— 3.5m in between.

A geological map of the seafloor, established from the processed and interpreted sonic profiles, was also used.

The fault locations were tentatively established by interpretation of the topographic map of the seafloor, and then the profiles were checked, if there was some clearly visible disturbance on the corresponding position on the sonic profiles. Only, when this was established, the probable fault was entered.

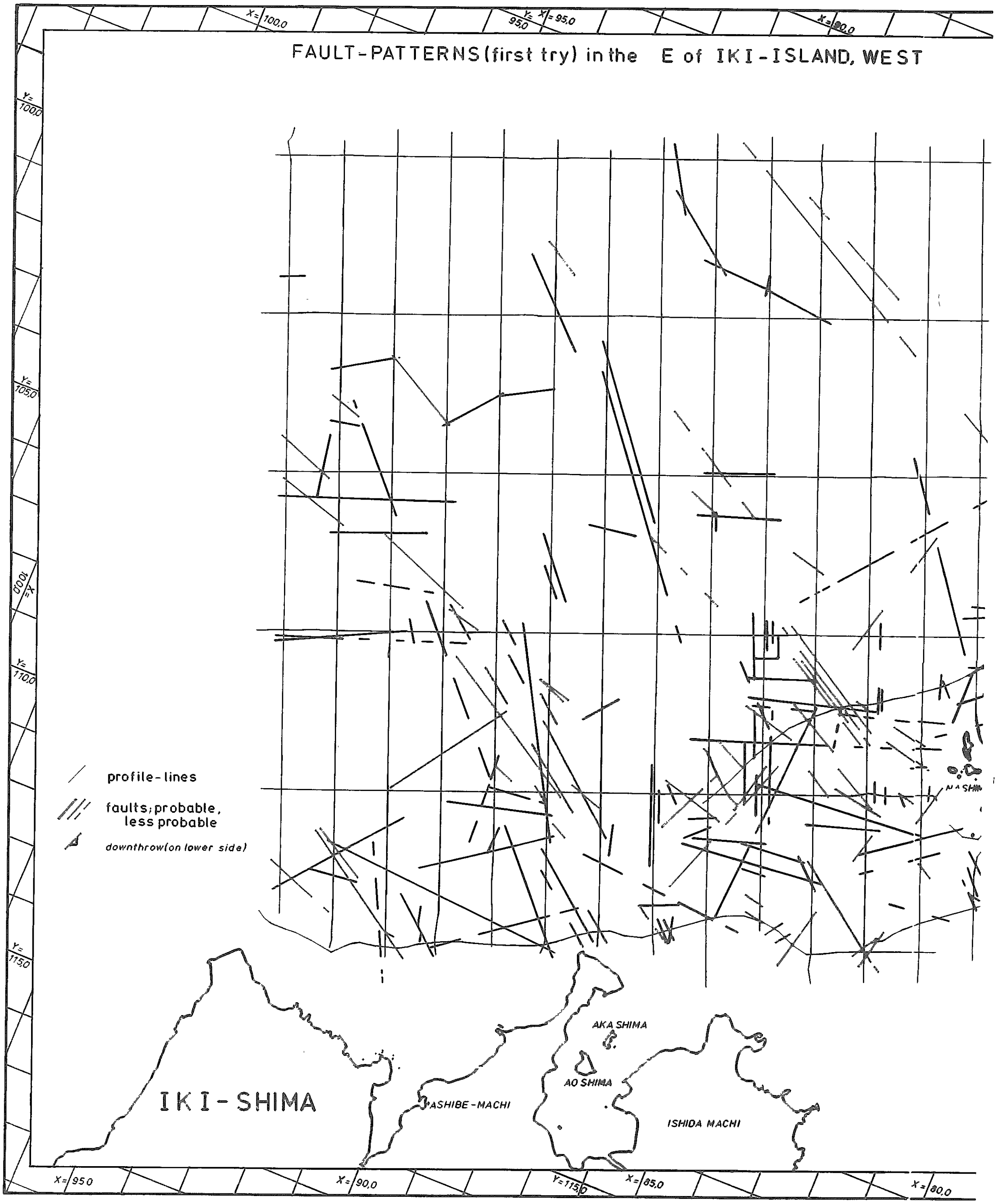


Fig.2. : Map of faults visible SE of Ikishima (first try).

RESULTS:

The different densities of faults on the map is more an effect of the mesh size of the survey and the seafloor topography, obscured partly by lava flows, than of the presence/absence of faults themselves. The different quality of the profiles also had some influence on the amounts of faults verifyable.

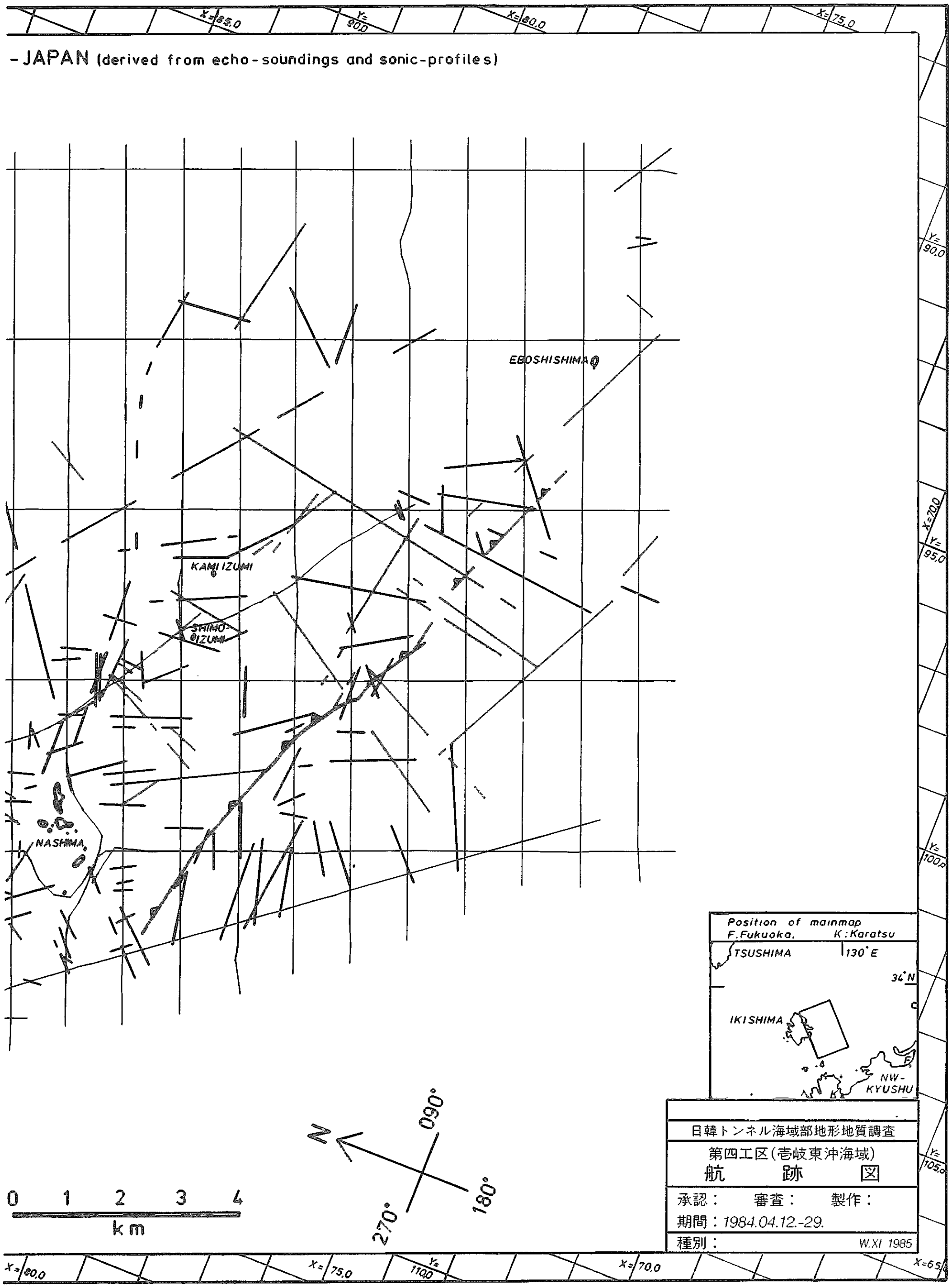


Fig.2. : Map of faults visible SE of Ikishima (first try).

Some of the readers will miss a statistical treatment or representation of the fault directions. This was purposely not done, because the faults made visible by this method are for sure not all the faults really present. So any statistics with an incomplete data-set would create an impression, which can not represent the actual situation, and would fix the thinking for the construction of the

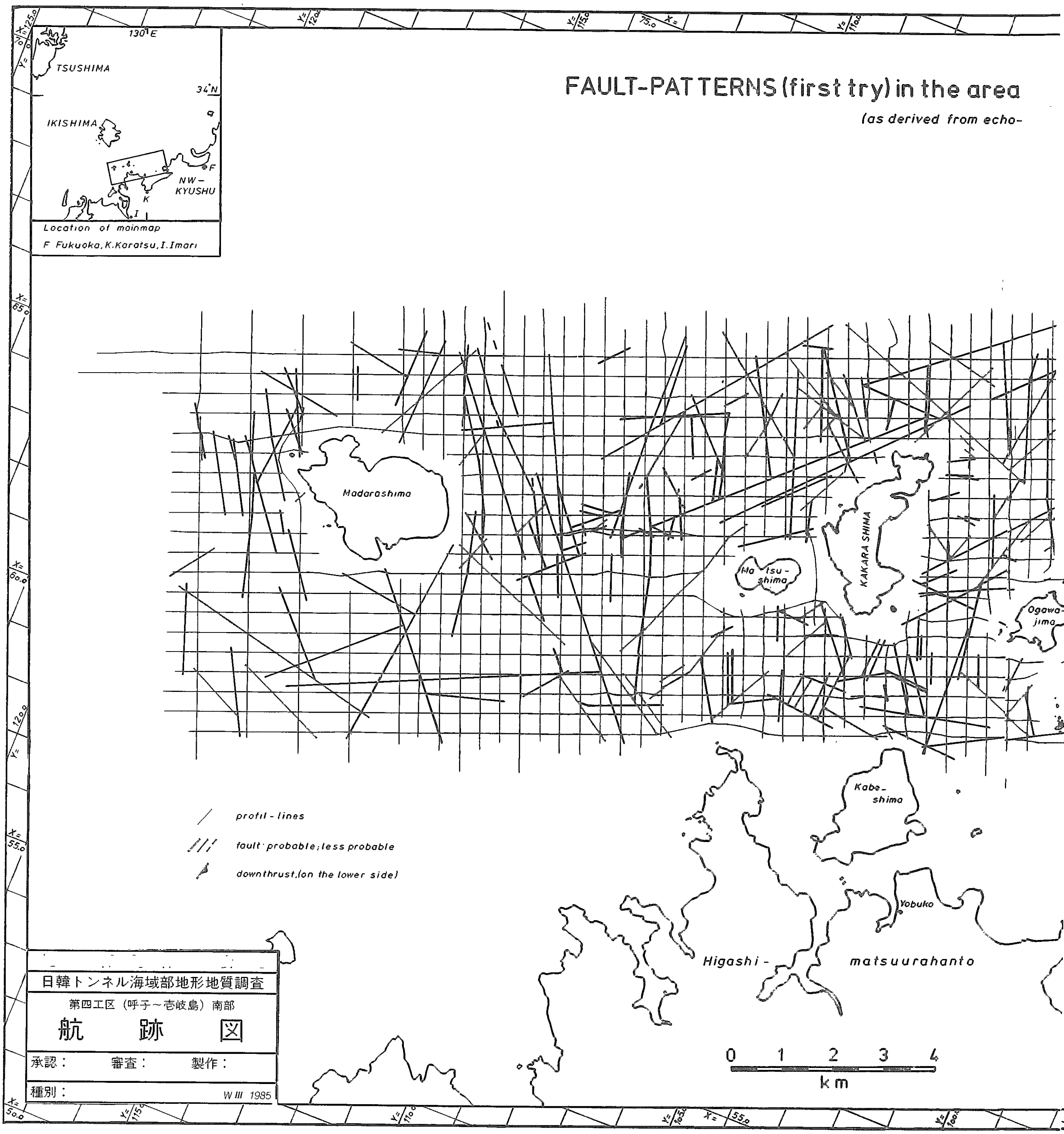
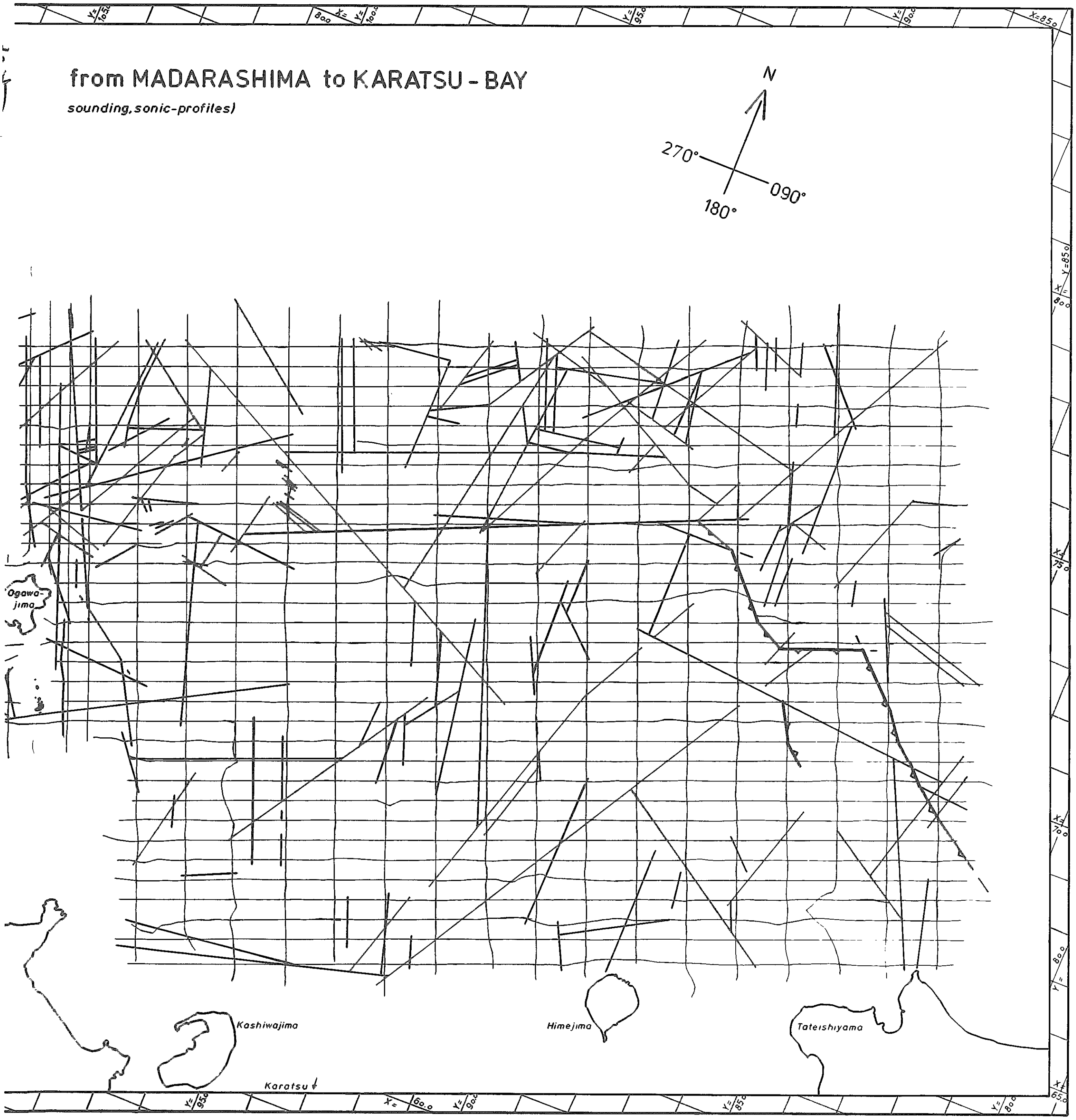


Fig.3. : Map of faults visible N of Yobuko (around Madarashima,

tunnel in a dangerous way.

With these limitations in mind, several areas were found to have a slightly higher concentration of two or more fault directions. These different areas are given in Fig.4. They are characterised and denoted in the 360°-system, from N (000) over E (090) to S (180) {comp. Fig. 5}, with only the eastern side of the strike direction written down directly, as



Matsushima, Kakarashima and Ogawashi-ma and in 'he bay of Karatsu) (first try) this is better computer compatible. :

SE of Ikishima from N to S :

a) 030—040°, 045—050°, 140—150° and 165—175° directions are somewhat noticeable in groups.

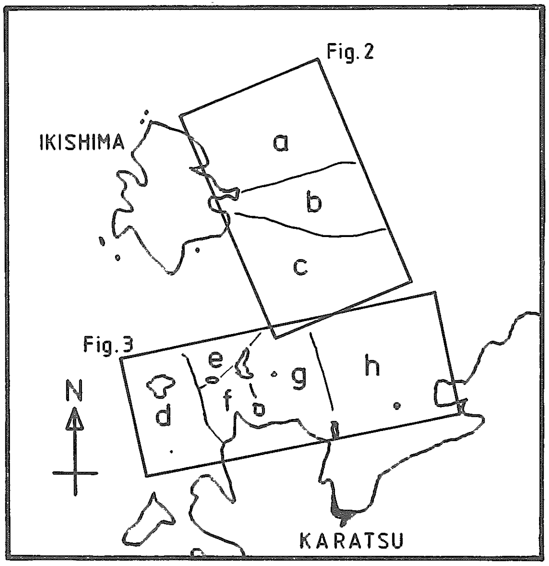


Fig.4. : Sketch of the areas which seem to have some more abundant visible directions.
(a - h: are explained in the text.)

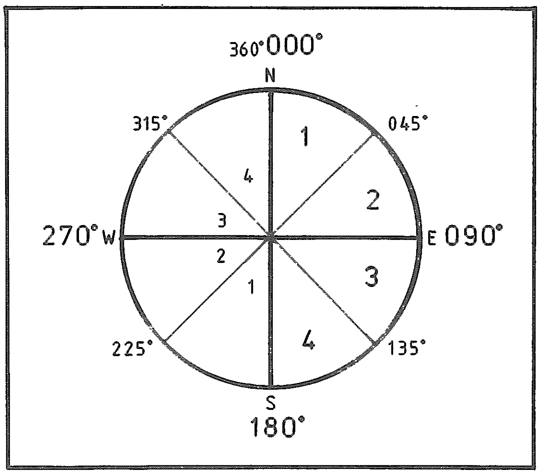


Fig.5. : Orientation diagramm based on the 360° reading of a modern two-cricle geological compass (sys tem Clar).
With outline for the quick-reference orientation notation for the strike of faults or planes.

b) 355—005°, 085—095°, 045—055°, 060—070° are a bit more prominent.

c) 045—050°, 065°, 150—175° are beside the SW-rim of the graben, which oscillates between 100°—140°, the more important lines. As the chain of volcanic islands to the SE of Ikishima is not necessarily just above the northeastern-escarpment of the graben, it is only possible to assume, that the NE-side runs more or less parallel to the south-western graben-rim.

The part N of Yobuko from Madarashima to Karatsu Bay from W to E:

d) 130—140° is the most visible direction around Madarashima.

e) 160—170° and 035—050°are in the part N—NW of Matsushima and Kakarashima the clearest appearing directions. The long continuous line with 050—060° is the southern rim of a depression, which is ending N outside of this map.

f) 355—005° and 085—095° form here seemingly a conjugate pair, and denote also some smaller depression.

g) With 160—170° and 030—050° it is similar to area e) but with some additional 090—100°.

h) In the area with wider spaced profile lines are faults with 160—170° and 075—090° visible in the northern part and the very southern rim, whereas 120—130° and 020—030° catch the eye with longer lines in the middle part.

The graben as such has the same general variation between 100° and 140°(with one offset with 070° strike) on both maps. It shall be noted, that in the region where the two maps overlap (north of the offset) the graben was not clearly visible in the profiles and therefore has also not been shown on the map. This could be a part where the graben is filled either with the surrounding material, or was not strongly developed in the beginning. A third, more remote, possibility would be, that at a later time this part of the graben was subjected to some uplift and erosion, so that faults have been copied through, but the graben was removed.

A continuation of the graben direction on Iki is sure and is likely towards the SE, leading to the W of the basin of Fukuoka.

FUTURE PLANS:

It is planned to install a series of geophones on the seafloor and to check the strata with sound waves from beneath, while the excavation is going on. If necessary with shots from the tunnel front, if the excavation should be done in a non-blast way. Through that we will get three dimensional information, which should allow us to determine exactly locations of fault-planes close ahead, as well as their correct inclination. This will give the best possible information about the area to be excavated next. With the continuous counter-check through excavation the accuracy will increase in time. It is considered as one of the best safeguards against surprises from these risks.

The length of the route will be divided in smaller sections of convenience and within each one the faults, which are close to the route, will be assigned a letter-number code for identification.

As an example : A- 4 -005 , where A, the first part, = the area, the second part - 4 - is the field of orientation (it has four steps of 45 degrees from the North over East to South; compare Fig. 5) and the third part -005 is the running number. The orientation has been incorporated to faciliate an evaluation of the possible influence at the intersection with the tunnel. Later the known dip direction and inclination of the fault will replace the general strike number, e.g. A-055/45-005 or A-235/75-005 replacing A- 4 -005 in the final documentation according to the dip-direction, which is more important for structural assessments than the strike direction.

The land areas will be naturally included. To cope with the higher information density on land smaller areas and bigger scaled maps will be necessary.

In the case a fault should be present in two adjoining areas, both area-letters are given and the running number does not change, e.g.: B- 4 -11 will become BC- 4 -11, when the fault proceeds into area C.

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