GEOLOGY OF THE NEW GUINEA FOLDBELT

Dave Klepacki
Foldbelt Symposium, October 24, 1989

New Guinea is located (Fig. 1) at the northern boundary of the Australian tectonic plate. The plate boundary is obliquely convergent with the Pacific plate moving at 253° (WSW) at 1.2 cm/yr with respect to the Australian Plate. This oblique collision results in both a southwesterly verging fold and thrust belt and major left-lateral strike-slip faults.

Most of the recent petroleum industry activity in New Guinea has focused along the fold and thrust belt, especially in Papua New Guinea (Fig. 2). Several major oil and gas accumulations have been discovered in the mid-eighties, principally by Nuigini Gulf, a consortium of Chevron, British Petroleum and minor interest holders. Numerous oil and gas seeps promise additional reserves yet to be discovered.

The Joint Australian New Guinea Indonesian Study (JANIS) was formed in 1987 to study the New Guinea foldbelt and guide Exxon's participation in the play. Team members were recruited from Esso Australia, Exxon International and Exxon Production Research Company. The principal methods for investigating the structural architecture of the foldbelt including supplimenting geologic maps with Landsat and Synthetic Aperature Radar imagery, constructing regional scale balanced cross sections and checking the structural interpretations with gravity modelling (where data were available, e.g. Figs 3,4). Most of the conclusions presented here arose from this study.

Most of the principal stratigraphic play elements (source, resevoir and seal) were deposited in Mesozoic time, prior to significant compressional structural development (Fig. 5). The fold and thrust belt developed in stages in Cenozoic time, with an Eocene stage largely confined to the present hinterland of the foldbelt and a middle Miocene and younger stage that is continuing to transgress southward. The younger stage developed most of the traps being prospected for hydrocarbons today. Maturation modelling indicates that foredeep and thrust sheet loading within the last 8 million years is generating hydrocarbons filling today's traps.

The JANIS Project divided the foldbelt into subdivisions characterized by particular fold and fault relationships (Fig. 6). The subdivisions include areas dominated by: fault-bend and fault-propagation folds, duplex zones, delta zones, thrust sheets with crystalline basement, and foreland basement-involved structures (Fig. 7). The distribution of these structural divisions depicts important along-strike variations in the thrust belt (Fig. 8). The segment of the foldbelt north of the Gulf of Papua is an imbricated wedge of Mesozoic rift/sag and Tertiary foredeep sediments (Fig. 8C). Only the extreme northern part of the foldbelt here includes basement thrust sheets. Towards the northwest, in central Papua, the basal detachment ramps laterally downward into crystalline rocks so that basement-involved sheets are involved in the frontal parts of the foldbelt. The location of the basement ramp is close to the transition of unextended continental crust of the Australian craton to extended continental crust underlying Mesozoic and Tertiary sedimentary basin north and east of the craton. Prior to basement-involved thrusting, the thrust wedge included only supracrustal rocks. This earlier thrust belt is now extinct and riding southward upon the basement-involved sheets (Fig. 8B). Large hanging-wall ramp anticlines of crystalline rock form the Juha, Muller (Fig. 3) and nearby anticlines. Basement-involved sheets continue to dominate the fold and thrust belt to the beginning of the "Bird's Neck" area of Irian Jaya. In the southern Bird's Neck area the basal detachment rises laterally out of crystalline rock into the Mesozoic sedimentary rocks. The principal detachment levels in this western sedimentary basin are near the base of the Mesozoic sequence and within Pliocene foredeep strata, thus creating thick thrust sheets with large fault-bend and fault-propagation folds (Fig. 8A). The number of thrust sheets comprising the foldbelt decreases towards the west, concurrent with the appearance of the Terera-Aiduna strike-slip fault which continues westward from the thrust belt to the Seram Trench. Northwest of the Terera-Aiduna fault, in the central and upper portions of the Bird's Neck area, the northerly-trending Lengguru Foldbelt diverges from the main WNW-ESE New Guinea Foldbelt trend. The Lengguru Foldbelt (Fig. 3) is structurally similar to the western part of the New Guinea Foldbelt. The thrustbelt consists of thick sheets of Meszoic through Pliocene strata. Intervening detachment levels are present mostly in the interior part of the Foldbelt where the Upper Cretaceous strata contain an important detachment horizon.

Besides hydrocarbon accumulations, an important aspect of the New Guinea Foldbelt is it's current geological activity - it provides a natural laboratory to study the processes of foldbelt dynamics. Abers and McCaffrey (1988) are involved in studying the earthquake activity on New Guinea and the nature of ongoing deformation in the Foldbelt. Maps of shallow seismicity (<70 km deep) of the area (Fig. 9) show an abundance of earthquakes at or near the leading edge of the Foldbelt. Most of these events have reverse or thrust fault focal plane solutions (Fig. 10). Events in the interior of the foldbelt tend to have deeper hypocenters (about 20 km) and probably originate at deep ramps along the basal fault. In the central part of the foldbelt (Fig. 11) where basement-involved sheets are present, left-lateral strike-slip faults occur in the interior parts of the foldbelt. These strike-slip events have hypocenters <u>above</u> reverse fault events suggesting the strike-slip faults are detached at the basal thrust. At the west end of the New Guinea thrust belt (Fig. 12) reverse and strike-slip earthquakes are intermixed. The nature of the transition from thrust belt to strike-slip fault is unclear. A single event at about 19 km depth along the Aiduna fault west of the thrust belt indicates the strike-slip fault there dips at 30° to the northwest! Our current level of understanding leads to the conclusion that the strain resulting from the oblique collision of the Pacific plate and the Australian Plate is partitioned into a southerly convergent component and a westerly left-lateral strike-slip component. Within the fold and thrust belt, the strike-slip component appears to be detached (Fig. 13), resulting in a flake of crust that is moving both south and west, relative to the Australian plate. Strike-slip faulting appears not to be a significant component of seismic deformation in the Papuan segment of the fold and thrust belt.

Joint Australia New Guinea Indonesia Study, December, 1987, Exxon Company International (EPRCo. Lib. Ref. No. RO12496)

Abers, G., and McCaffrey, R., 1988, Active deformation in the New Guinea Fold-and-Thrust Belt: Seismological evidence for strike-slip faulting and basement-involved thrusting. Journal of Geophysical Research, v.93, No. B11, p. 13,332-13,354.

Basins of New Guinea

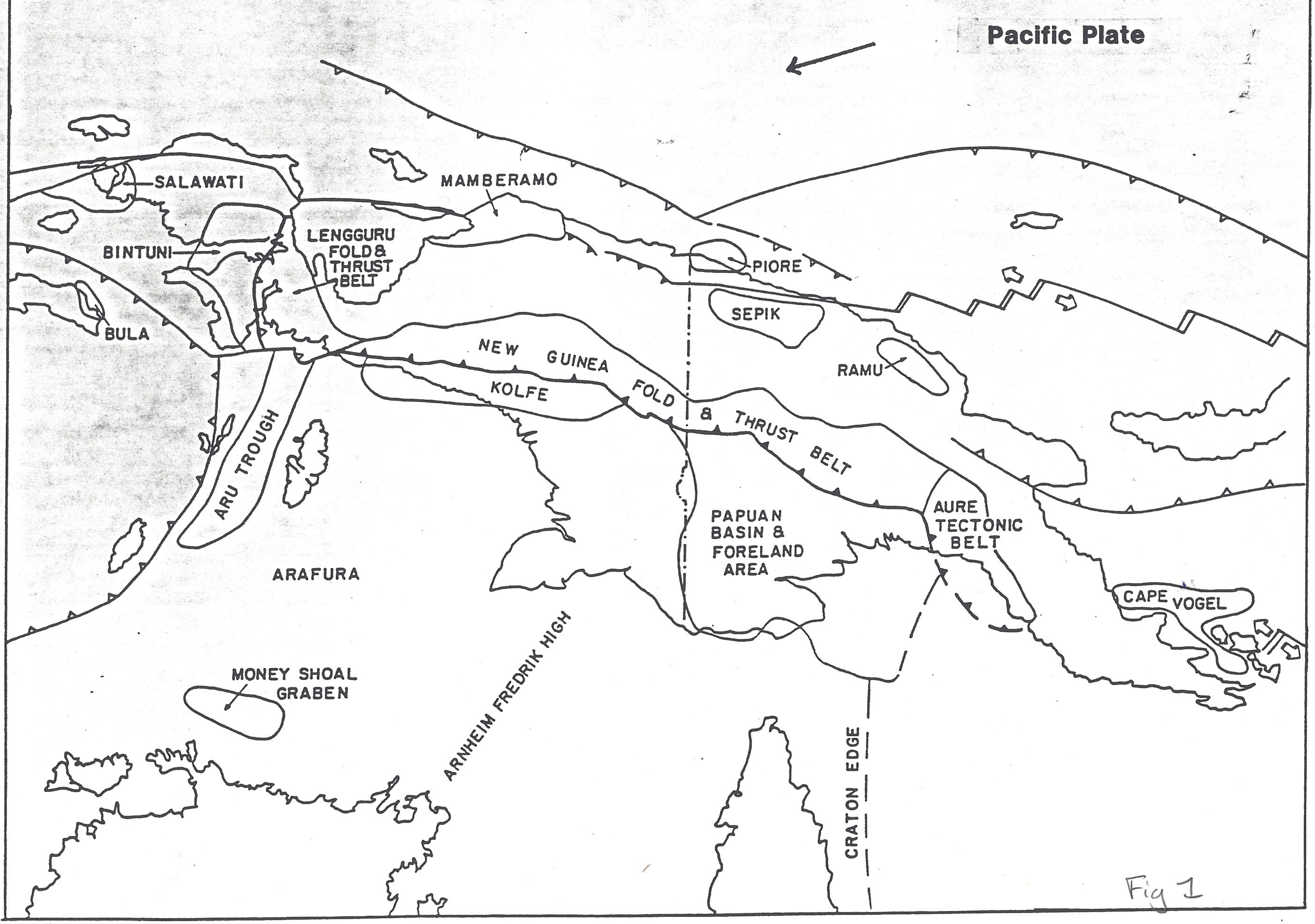


Fig 1

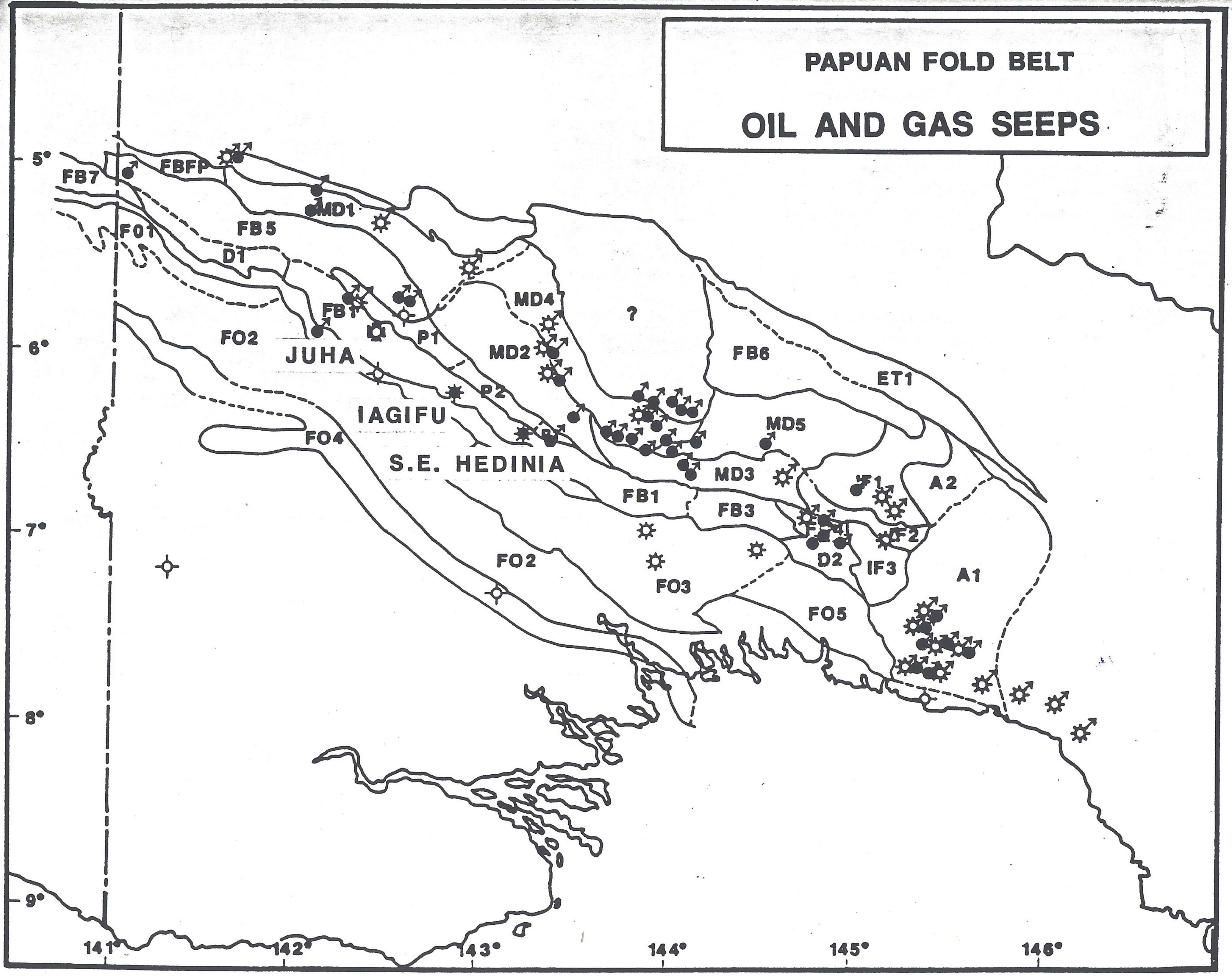
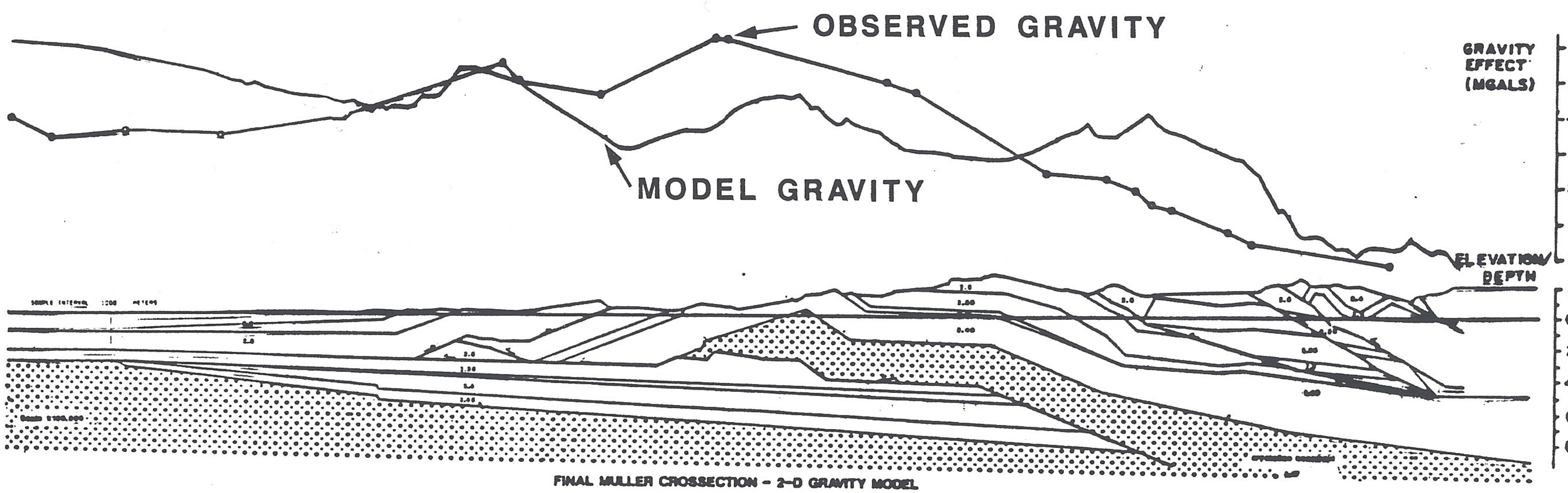

PAPUAN FOLD BELT
OIL AND GAS SEEPS
5°
6°
7°
8°
9°
141°
142°
143°
144°
145°
146°
FB7
FBFP
MD1
FB5
FO1
D1
FB1
P1
MD4
MD2
?
FB6
ET1
FO2
JUHA
P2
IAGIFU
FO4
S.E. HEDINIA
MD5
MD3
FB1
FB3
IF1
A2
IF2
D2
IF3
A1
FO2
FO3
FO5

Fig 2

PRELIMINARY MULLER CROSSECTION - 2-D GRAVITY MODEL



FINAL MULLER CROSSECTION - 2-D GRAVITY MODEL

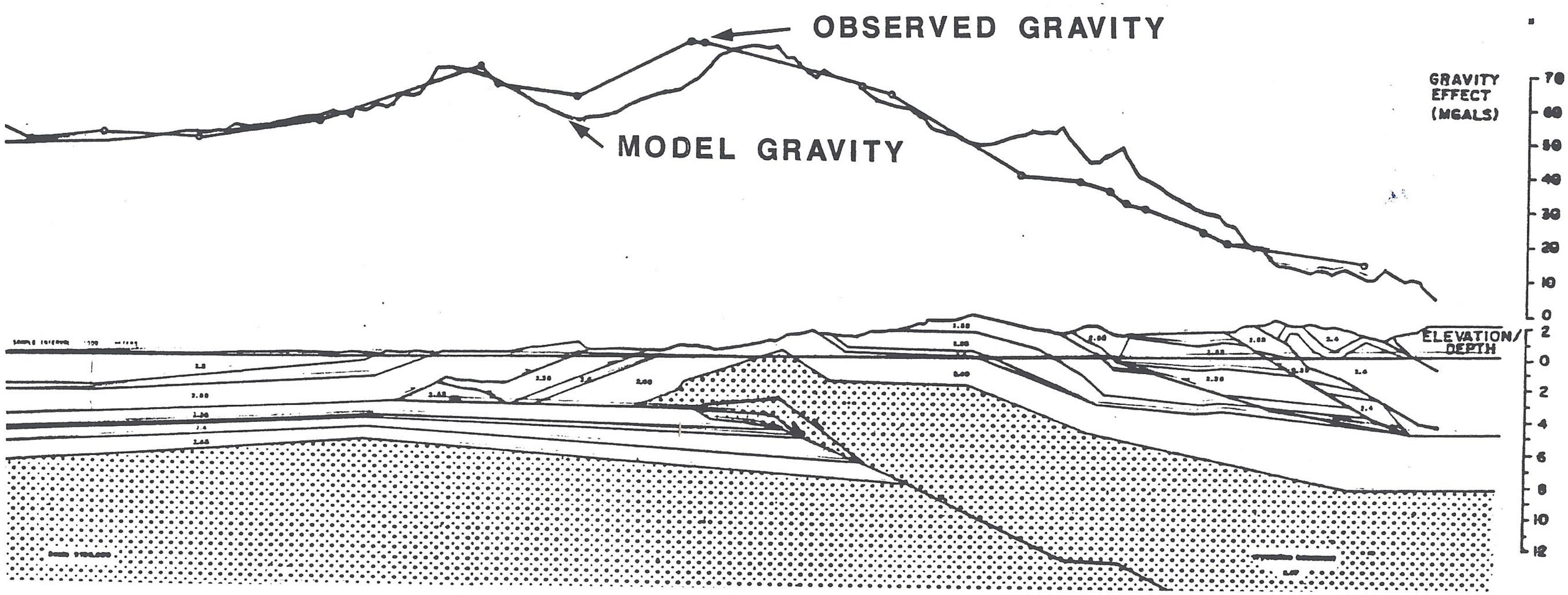
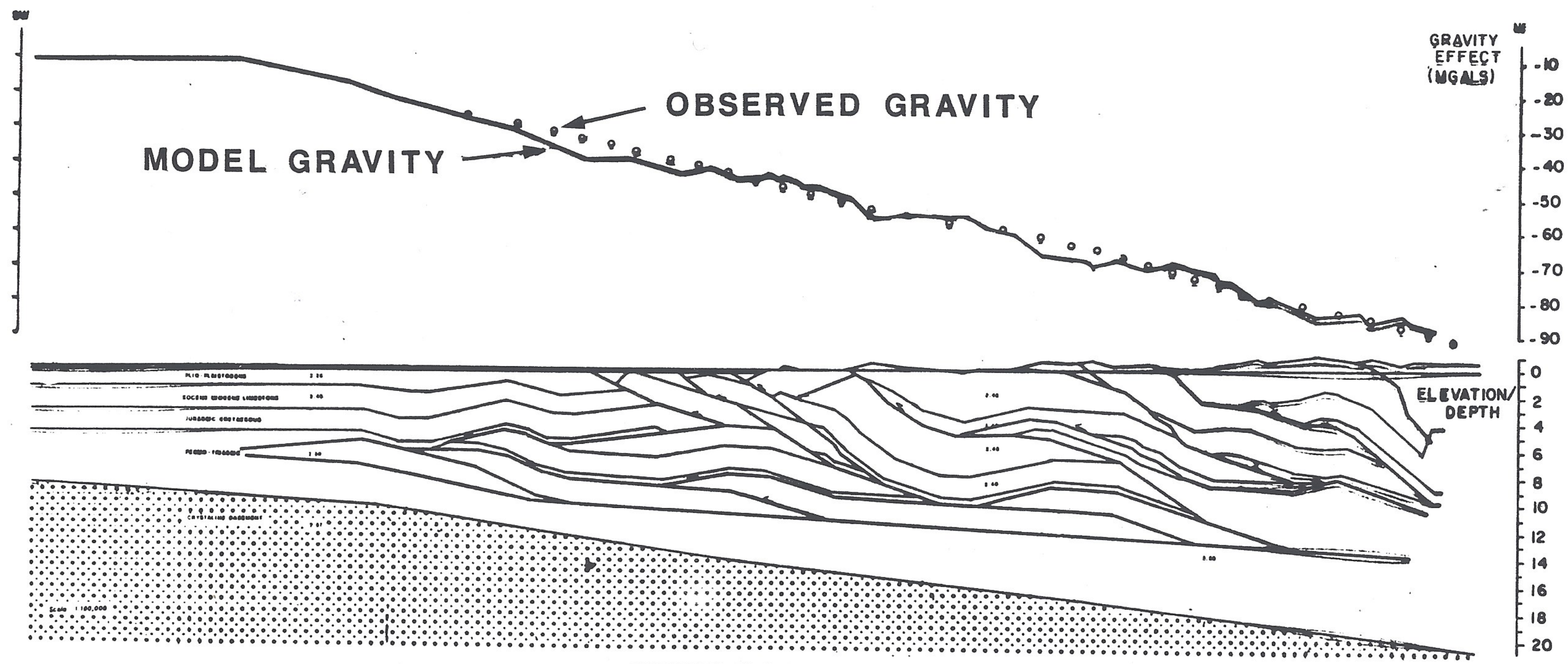


Fig 3

LENGGURU CROSS SECTION 2-D GRAVITY MODELS

DETACHMENT MODEL



BASEMENT INVOLVED MODEL

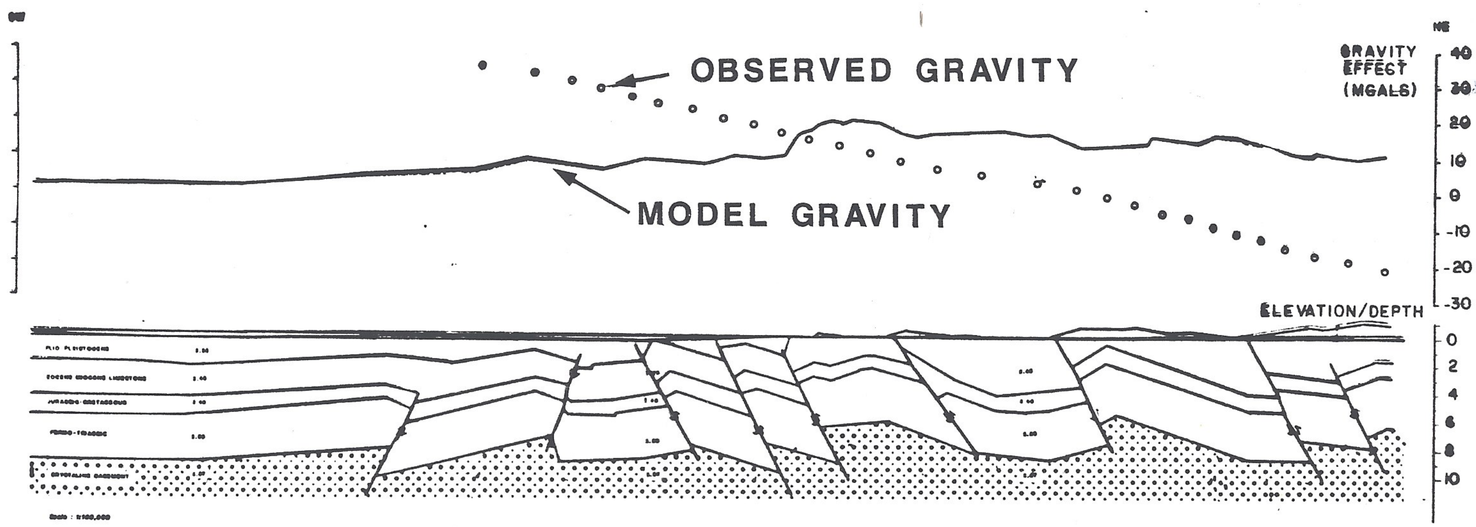


Fig 4

TECTONIC HISTORY OF THE J.A.N.I.S. AREA

- MESOZOIC RIFTING THAT FORMED NORTHERN MARGINS OF AUSTRALIA AND SOURCE, RESERVOIR, AND SEAL ELEMENTS

    PERMIAN-JURASSIC INTRACONTINENTAL RIFTING ALONG NORTHWEST SHELF

    PERMIAN-JURASSIC BACK-ARC RIFTING ALONG NORTHERN NEW GUINEA AND NORTHEAST AUSTRALIA

    MIDDLE CRETACEOUS-PALEOCENE RIFTING CREATING CORAL SEA AND LATE CRETACEOUS PLAY IN EASTERN PAPUA

- CENOZOIC COLLISION WITH PACIFIC AND SOUTHEAST ASIAN PLATES CREATING TRAP ELEMENTS

    EOCENE OBDUCTION OF OCEANIC CRUST

    MIOCENE ARC COLLISION AND ACCRETION

    - o DEVELOPMENT OF THRUST BELTS
    - o EXTENSIONAL COLLAPSE OF ARC, NORTHERN SUCCESSOR BASINS
    - o WESTWARD TRANSLATION OF CRUSTAL RIBBONS FROM NORTHERN NEW GUINEA AND DEVELOPMENT OF BANDA SEA

    PRESENT CONTINUED OBLIQUE CONVERGENCE ALONG THRUST BELT AND LEFT-LATERAL STRIKE SLIP FAULTS

Fig. 5

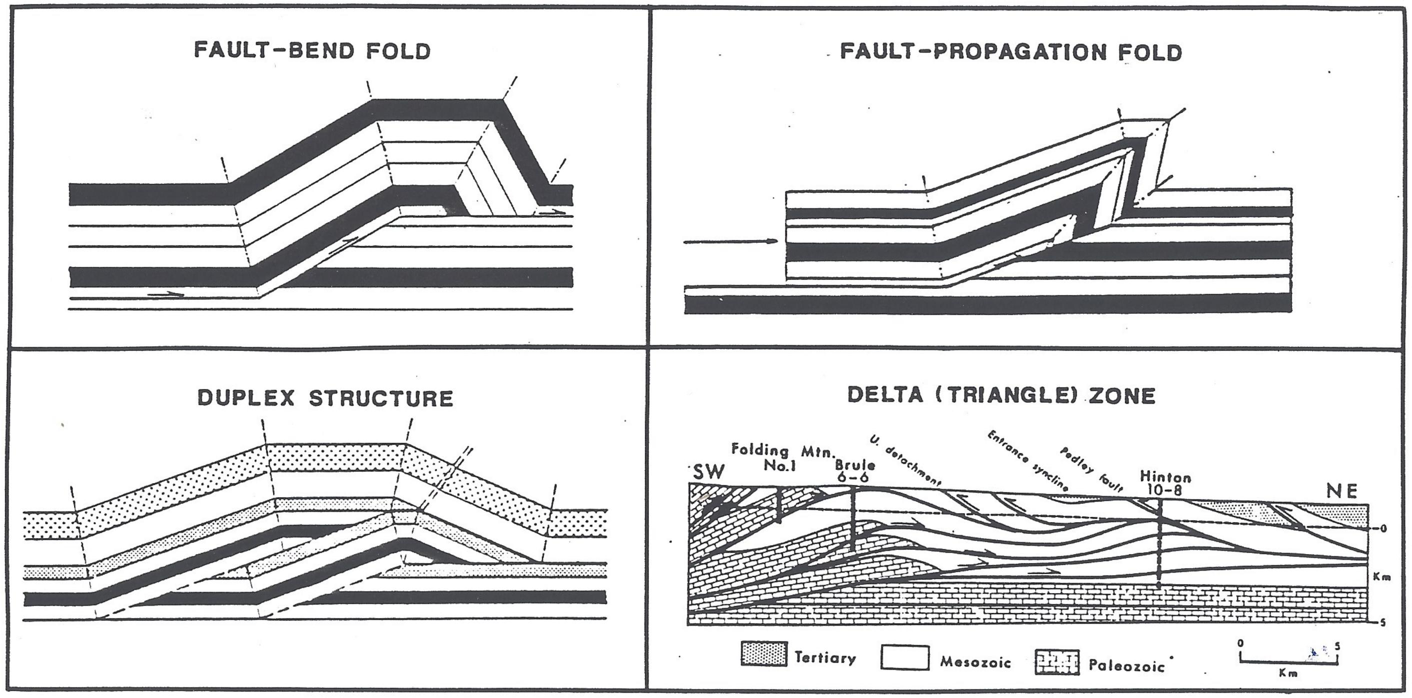
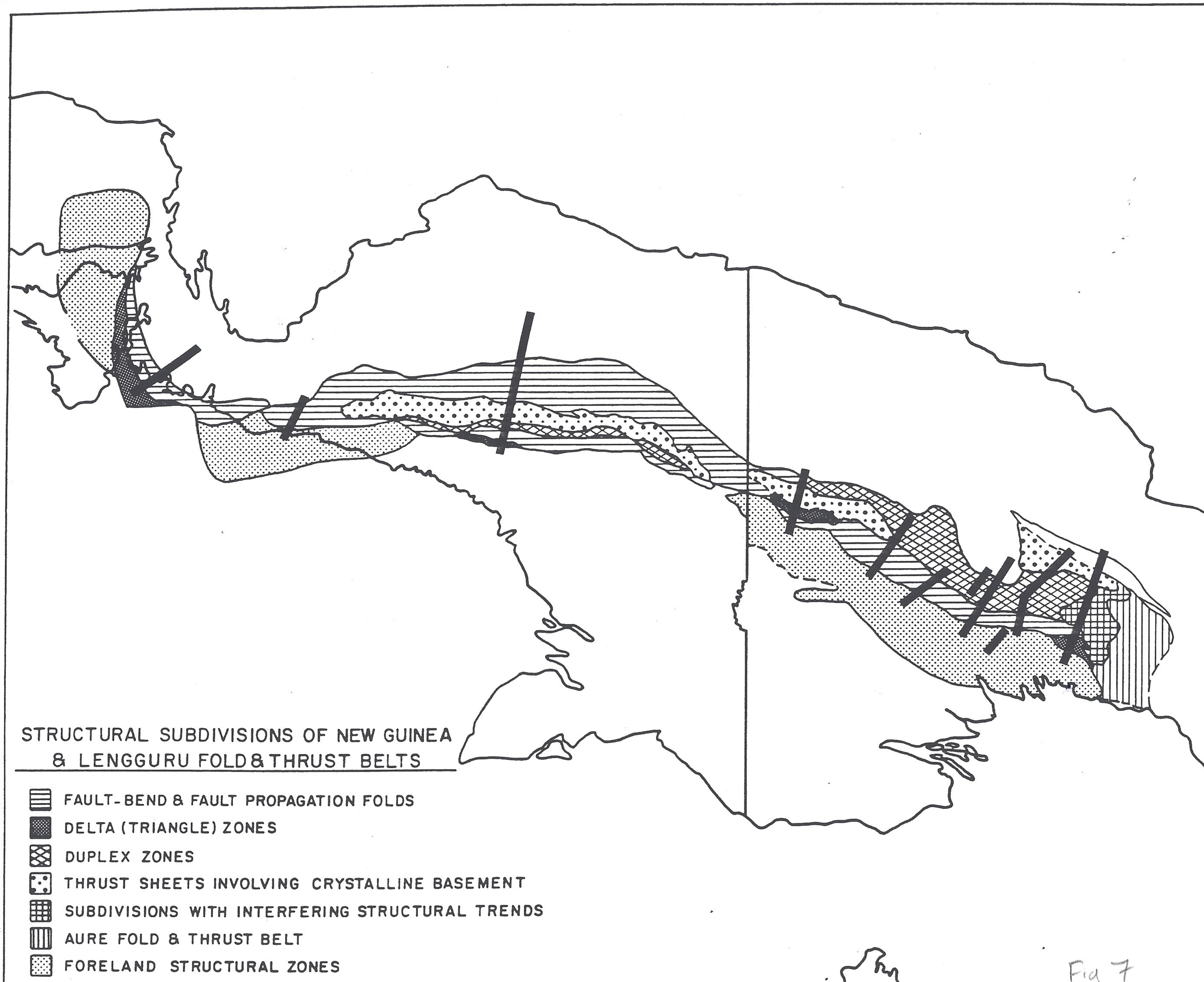

FAULT-BEND FOLD
FAULT-PROPAGATION FOLD
DUPLEX STRUCTURE
DELTA (TRIANGLE) ZONE
SW
Folding Mtn. No.1
Brule 6-6
U. detachment
Entrance syncline
Pedley fault
Hinton 10-8
NE
0
Km
5
Tertiary
Mesozoic
Paleozoic
0
5
Km

Fig. 6



STRUCTURAL SUBDIVISIONS OF NEW GUINEA
& LENGGURU FOLD & THRUST BELTS
FAULT-BEND & FAULT PROPAGATION FOLDS
DELTA (TRIANGLE) ZONES
DUPLEX ZONES
THRUST SHEETS INVOLVING CRYSTALLINE BASEMENT
SUBDIVISIONS WITH INTERFERING STRUCTURAL TRENDS
AURE FOLD & THRUST BELT
FORELAND STRUCTURAL ZONES

Fig 7