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Filtering SEASAT and GEOS-3 satellite altimeter data in the South West Pacific

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DU 30 SEPTEMBRE 1986

INSTITUT FRANÇAIS DE RECHERCHE SCIENTIFIQUE
POUR LE DÉVELOPPEMENT EN COOPÉRATION

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FOREWORD

This work has been carried out by ORSTOM at the request of the Committee for Co-Ordination of Joint Prospecting for Mineral Resources in South Pacific Offshore Areas (CCOP/SOPAC). CCOP/SOPAC has provided the financial grant. The data have been processed with the collaboration of the Laboratoire de Géophysique de l'Université de Paris-Sud.

I wish to thank particularly G. Gabalda who processed the data using C.N.R.S. equipment of the C.I.R.C.E (Orsay, France), and M. Diament for his usefull help during this work. I also thank R.H. Rapp for providing us the SEASAT and GEOS-3 data sets.

This report constitutes the final report referring to the contract between ORSTOM and CCOP/SOPAC (September 30, 1986).

This report contains a set of four maps of the filtered SEASAT and GEOS-3 altimeter data, and a map on which are reported the new uncharted features.

DATA PROCESSING

The major purpose of this work is to display the short wavelength information of the SEASAT and GEOS-3 satellite altimeter data in order to detect uncharted seamounts in the Southwest Pacific. The studied area is bounded by 140°E - 155°W and 5°N - 40°S.

We used the SEASAT and GEOS-3 data prepared by Liang (Liang, 1983) who put the GEOS-3 data set in the same system as the adjusted SEASAT data set and make them consistent which each other. In order to remove the very long wavelengths of the geoid unrelated to the bathymetry, we have substracted a GRIM3 (10,10) global geoid model (Reigber et al., 1983).

The altimetric profiles have then been bandpass filtered using a digital third order Butterworth filter. Phase shifts caused by the recursive character of the filter were removed by filtering the data in a forward and backward sweep along the tracks. Attenuation was 72 dB/octave, and the cutoff frequencies was determined from 1) the GEOS-3 and SEASAT altimeters resolution capabilities, and 2) seamounts signature on the altimeter profiles.

1) The altimeter capabilities have been studied by many authors, as Brammer and Sailor (1980), Tapley et al. (1982), Marks and Sailor (1986). They conclued that the short wavelength resolutions was about 30 km for SEASAT and about 60 km for GEOS-3.

2) Seamounts produce on the local geoid anomalies which width and amplitude are about 150 km and 1-2 m respectively (Watts and Ribe, 1984).

So, in order to keep the maximum energy of the altimetric signal due to the seamounts effects, we chose to filter the data in the 35-245 km band for SEASAT and in the 70-245 km band for GEOS-3.

After processing the ascending and descending SEASAT and GEOS-3 tracks, we plotted the filtered data using a color representation of the geoid heights. Compared with order graphical representation of the processed altimeter date (see for example Sandwell, 1984a), this representation allows to display on the same map both ascending and descending tracks, and makes the interpretation easier. The data sets were divided in four geographical regions in order to be displayed at the same scale as the bathymetric map of Kroenke et al. (1983). We used Mercator projection and the scale at the equator is 1:6,442,192.

Amplitudes of the residual geoid heights are represented according to a color scale from -0.85 m to 1.45 m.

SIGNATURE OF TOPOGRAPHIC STRUCTURES

TRENCHES

Trenches appear clearly as high amplitude negative anomalies of about -0.3 to -0.8 m. All the active subduction trenches, and some fossil ones like Vitiaz Trench, are clearly identifiable. On both sides of the subduction zones are some positive anomalies which are the effect of the Butterworth filter, and are not necessary correlated with positive topographic features.

RIDGES AND SEAMOUNTS CHAINS

In the N-E prolongation of the Nova Canton Trough, some isolated seamounts are reported on the bathymetric map, but the filtered altimeter data show clearly a continuous ridge extending from about 165°W to the Northern Line Islands.

In the North Penrhyn Basin, two seamounts are located at about 160°W 5.5°S. In fact, these seamounts are part of a ridge or seamount chain since a E-W positive anomaly extends on about 250 km.

SEAMOUNTS

The processed altimeter data reveal on the studied area 50 geoid anomalies which can be identified as typical seamount signatures in addition to those related to known seamounts. These seamount signatures do not correspond to any charted seamounts on the bathymetric map.

The typical seamount signature is a high frequency positive anomaly, which amplitude after filtering vary from 0.3 to more than 1 m, depending on the seamount volume, the isostatic compensation and the cross-track distance between the altimeter profile and the seamount. The width of the anomaly, for signal amplitude higher than 0.25 m, is about 50 km. In most case, the anomaly is detectable on more than one profile, and the sub-circular form of the anomaly can be tested.

The introduction of side lobes (negative amplitude) around the positive anomaly is a classical effect of the Butterworth filter (Vogt et al., 1984), and must not be interpreted as the gravity moats naturally present around any seamount which is regionally compensated by lithosphere flexure.

Before interpreting anomalies as seamount signatures, we must take care to some possible artefacts, which can be due to abrupt stops of the tracks, or to the proximity of some very high amplitude anomalies like anomalies associated with subduction zones.

In Table 1 we have reported the location of 50 uncharted seamounts, identified by a number on the map. We only report the geoid anomalies for which the confusion with artefacts or other topographic or nontopographic structures was very improbable.

LOCATION ACCURACY : The location accuracy of the detected seamounts is about 40 km. This low accuracy is firstly due to the possible cross-track distance between the altimeter profiles and the seamounts (see Lazarewicz and Schwank, 1982; White et al., 1983; Dixon et al., 1983; Sandwell, 1984b). Using modelisation of the geoid anomalies above seamounts, it is possible to have a 15 km precision on the seamounts location (Baudry et al., 1987); the reliability of this method has been demonstrated with SEABEAM survey on predicted seamounts during the SEAPSO ship cruise in the Austral islands (Pontoise et al., 1986; Baudry and Diament, 1987). One of these surveyed seamounts is the seamount S6 located near the south-east boundary of the area. But such a possible determination of the precise location is not the purpose of the present preliminary study.

SIZE AND SHAPE OF THE SEAMOUNTS : Amplitude and wavelength of the positive geoid anomaly associated with a seamount depends on several parameters such as the seamount size and shape, the cross-track distance between the seamount and the altimetric profile, and the isostatic compensation mechanism of the seamount. A direct estimation of the size and shape of detected seamounts is then unreliable.

Three of these uncharted seamounts were detected during previous works using SEASAT data (see Table 1).

OTHER GRAVIMETRIC STRUCTURES

Some wide positive geoid anomalies uncorrelated with bathymetric data are present in the d'Entrecasteaux Basin (structures S1, S2 and S3 on the bathymetric map. The geoid anomalies associated with the West Torres Plateau and Sabine Bank extend beyond the western boundaries of the bathymetric features. A large positive anomaly also appears on the north border of the d'Entrecasteaux Ridge. The wide of the anomalies and the relatively dense bathymetric data in the area (Jouannic, 1975) exclude that these anomalies correspond to uncharted bathymetric structures. We think that these anomalies are generated by crustal or subcrustal dense materials.

Other positive anomalies apparently uncorrelated with bathymetric features lie in the axe of the south Caledonia Basin (S5 and S6) and in the north of the Lord Howe Rise (S4).

CHARTED FEATURES WITH NO GEOID SIGNATURE

Some charted seamounts reported on the Kroenke et al. map are not associated with any significant geoid undulation. These doubtful structures have been noted "M" on the bathymetric map. We think that these seamounts do not exist or are mispositioned. Such was the case for Fabert Bank in the Southern Cook Islands. The SEAPSO cruise has shown that effectively no seamount was present on the charted location of Fabert Bank (Pontoise et al., 1986; Baudry and Diament, 1987).

CONCLUSIONS

A simple treatment of the SEASAT and GEOS-3 radar altimeter data has shown the existence of 50 uncharted major seamounts in the Southwest Pacific area. The location accuracy of the seamounts is about 40 km. A precise numerical study of the altimeter data would be necessary in order to determine with a high degree of reliability the size, shape and precise location of the seamounts. A 15 km accuracy would be very important for later oceanographic cruise. Indeed, such a 15 km accuracy on the seamounts location makes possible an easy marine survey with ships even equiped with traditional echosounding equipment. The seamounts would then be detectable on the first ship crossing over the predicted locations.

TABLE 1 - LOCATION OF THE DETECTED SEAMOUNTS
The location accuracy is about 40 km

Seamount	Latitude	Longitude	
1	3.5° N	154.4° E	
2	1.0° N	152.4° E	
3	2.7° N	159.5° E	
4	0.9° S	172.0° E	
5	2.7° S	165.0° E	
6	3.3° S	164.6° E	
7	4.2° S	161.5° E	
8	14.7° S	156.8° E	
9	17.7° S	158.9° E	
10	30.2° S	167.4° E	
11	29.8° S	172.1° E	
12	31.2° S	171.5° E	
13	31.8° S	173.7° E	
14	1.7° N	176.5° E	
15	1.5° N	176.0° E	
16	0.7° S	178.0° E	
17	6.0° S	179.6° E	
18	1.7° N	177.5° W	
19	1.8° N	171.9° W	
20	4.8° S	177.0° W	
21	5.4° S	176.0° W	
22	4.0° S	173.0° W	
23	0.6° S	170.7° W	
24	3.6° N	166.2° W	
25	1.0° N	161.3° W	
26	1.5° N	159.4° W	
27	1.9° S	156.2° W	
28	3.4° S	155.7° W	
29	4.1° S	163.7° W	
30	8.6° S	162.3° W	
31	7.5° S	160.6° W	
32	11.7° S	177.8° W	
33	12.4° S	171.4° W	
34	13.3° S	164.0° W	
35	14.9° S	163.8° W	
36	15.1° S	156.9° W	
37	18.1° S	157.1° W	
38	18.1° S	164.3° W	
39	22.5° S	178.1° E	
40	22.7° S	179.6° E	
41	27.4° S	171.0° W	
42	36.0° S	171.8° W	
43	33.7° S	172.6° W	
44	36.8° S	171.1° W	(3)
45	36.0° S	169.6° W	
46	36.8° S	169.8° W	
47	37.6° S	169.0° W	(3)

48	37.2° S	167.2° W	(1)	(2)
49	36.9° S	166.7° W		
50	37.8° S	158.6° W		

(1) Previously detected by Cazenave and Gominh (1984)

(2) Previously detected by Dixon and Parke (1983)

(3) Previously detected by Sandwell (1984b).

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