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Magnetic pattern of the FAMOUS zone

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Abstract. — Surface magnetic anomalies in the Famous area define a typical zebra pattern related to sea floor spreading. This pattern is symmetrical and corresponds to a 1.1 cm/yr half spreading rate up to anomaly 3'. The axis of the central block is off-set from the topographic axis of the rift and indicates either asymmetric spreading in the central zone or a ridge axis jump. These two hypotheses are discussed. —

Caractéristiques magnétiques de la zone FAMOUS

Résumé. — A partir des données magnétiques de surface, un réseau d'anomalies positives et négatives parallèle au rift médio-atlantique est mis à jour. Ce réseau est symétrique par rapport à l'anomalie centrale. Il correspond à un modèle d'épanchement de croûte océanique au demi-taux de 1,1 cm/an et ce jusqu'à l'anomalie 3'. L'axe du bloc central du modèle est décalé par rapport à l'axe topographique du Rift, suggérant soit un épanchement asymétrique, soit un saut de dorsale. Ces deux hypothèses sont discutées. —

Introduction.

Total field magnetic data has been gathered in the FAMOUS area during several cruises from 1972 to 1974 aboard N. O. *d'Entrecasteaux*, N. O. *Jean Charcot*, and N. O. *Le Noroît*. Data cover the northern half of the FAMOUS ridge segment located between fracture zones A and B [Needham and Francheteau, 1974].

Magnetic data have been corrected for the regional field using I.G.R.F. 1965. Residual magnetic anomalies have been projected at right angle to the ship tracks for the ones perpendicular to the rift axis (trend 020ºN). Over the central rift itself, more crossings were available and the projected anomalies are shown in the inset in the bottom left corner of figure 1.

Several observations can be made from these data. First of all, there exist some strongly lineated anomalies parallel to the rift axis up to 30 nautical miles from the axis with amplitudes of a few hundred gammas. Beyond that distance, the magnetic anomalies are not lineated anymore and cannot be correlated from profile to profile, their wavelength increase sharply to the east (no data available to the west).

Secondly, the central magnetic anomaly exhibits a double peak with intensities decreasing rapidly to the south. On both flanks of the central anomaly, small upward inflexions can be observed on most profiles.

Thirdly, the relative amplitude of the anomalies from the most external to the central ones, does not increase, but stay rather uniform.

Interpretation.

Using only 1973 cruise data (in order to avoid secular variations), a correlation of positive and negative anomalies has been made and a zebra pattern typical of ocean spreading has been obtained (fig. 2). The pattern is clearly symmetrical with respect to the central rift anomaly. Trend of anomalies is 020ºN for the central ones and 045º for the most external one. In order to model this pattern, a 400 meters thick, 1500 meters deep uniform slab of 0.01 emu/cc susceptibility was used together with the time scale determined for the Reykjanes ridge in a detail survey [Talwani *et al*, 1971]. Small variations seen in the trend of the magnetic anomalies would result in small variations of spreading velocity and in limited asymmetry but these were not judged significant. Figure 2 shows the correspondence between one observed magnetic profile and the magnetic anomaly of the model finally choosen. Half-spreading rate used is 1.1 cm/yr. Stacking of

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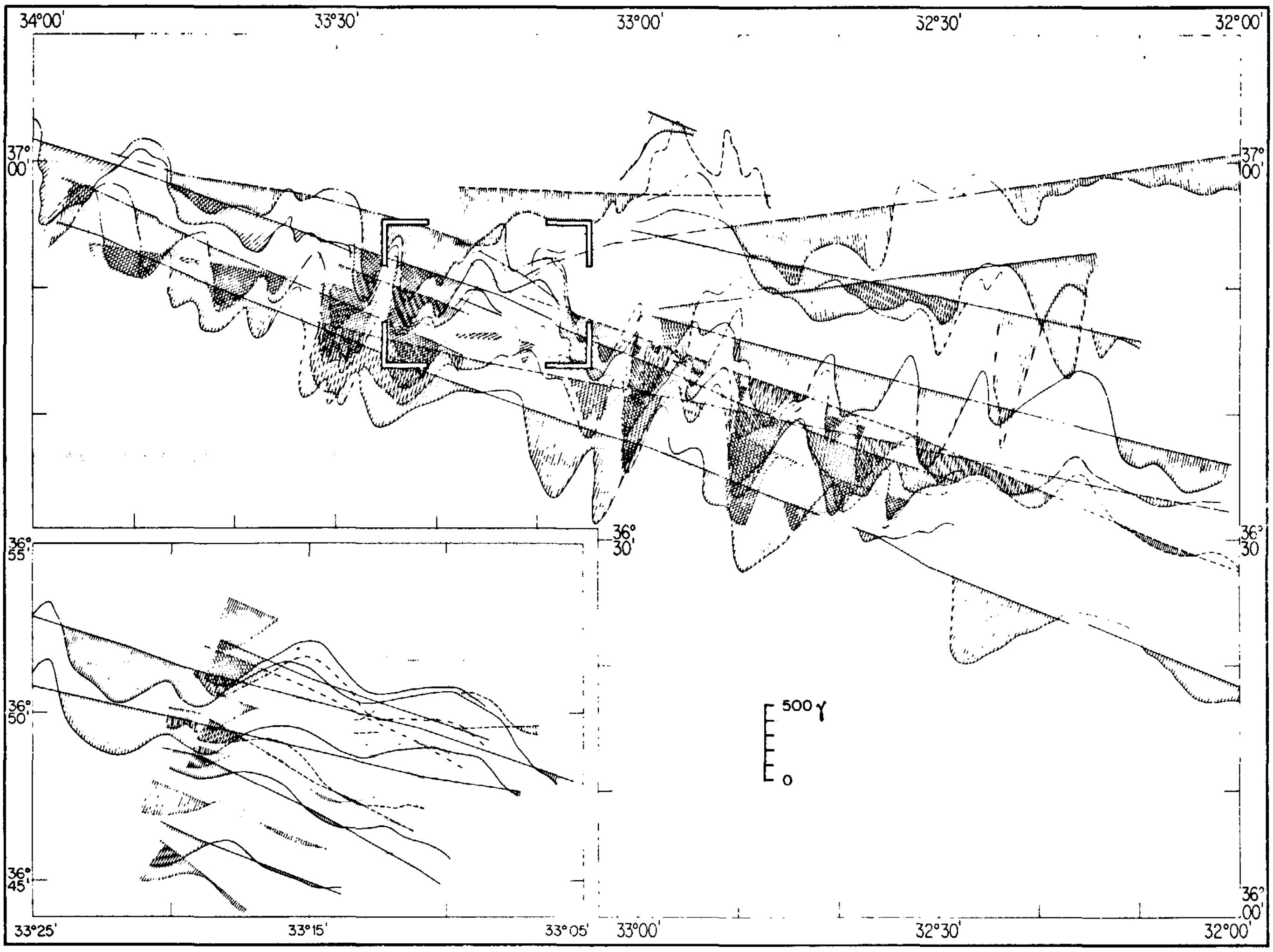

Fig. 1. — Magnetic anomalies map. Residual magnetic anomalies are projected at right angle to the tracks. Negative anomalies are shaded. Inlet shows details of the central magnetic high.

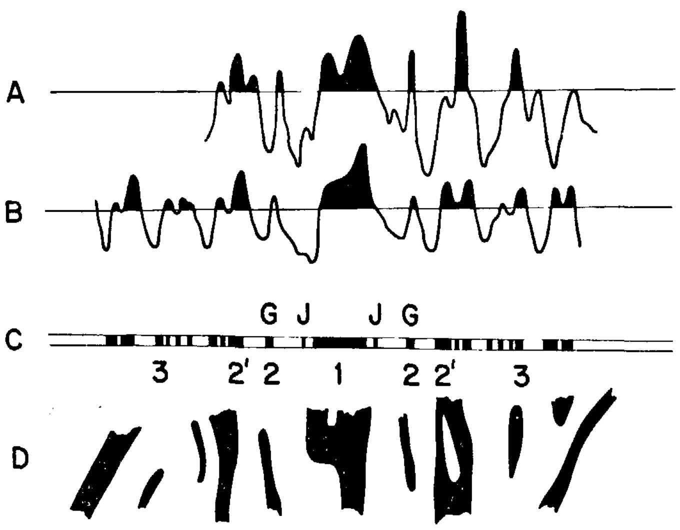

Fig. 2. — Magnetic model for the Famous rift.
A : Observed magnetic anomalies ; B : Computed magnetic anomalies for a 1.1 cm/yr half-spreading rate ; C : Magnetic Model ; D : Zebra pattern of magnetic anomalies, black above zero gamma.

the profiles was not thought advisable because a clear correlation exists between noisy anomalies and localised topographic features. The northernmost profile for example is clearly associated with fracture zone A. Stacking would also have reduced a well displayed correlation between magnetic trends and bathymetric ones (fig. 3). The model could not be tied to more regional anomalies such as anomaly 5 mostly due to the change in trend from 020°N to 045°N around anomaly 3. Long profiles to the east show that what could be anomaly 5 coincides with a rapid drop in bathymetry from 2000 meters to abyssal plain depth. Bathymetric profile from the rift to and beyond anomaly 5 does not correspond to an exponential thermal evolution profile and therefore spreading up to and beyond 5 has probably not been uniform. Additional data would be required to build a model beyond anomaly 3. Support for the model proposed comes from the very good correlation between observed and computed anomalies. It also comes from the good agreement with sprea-

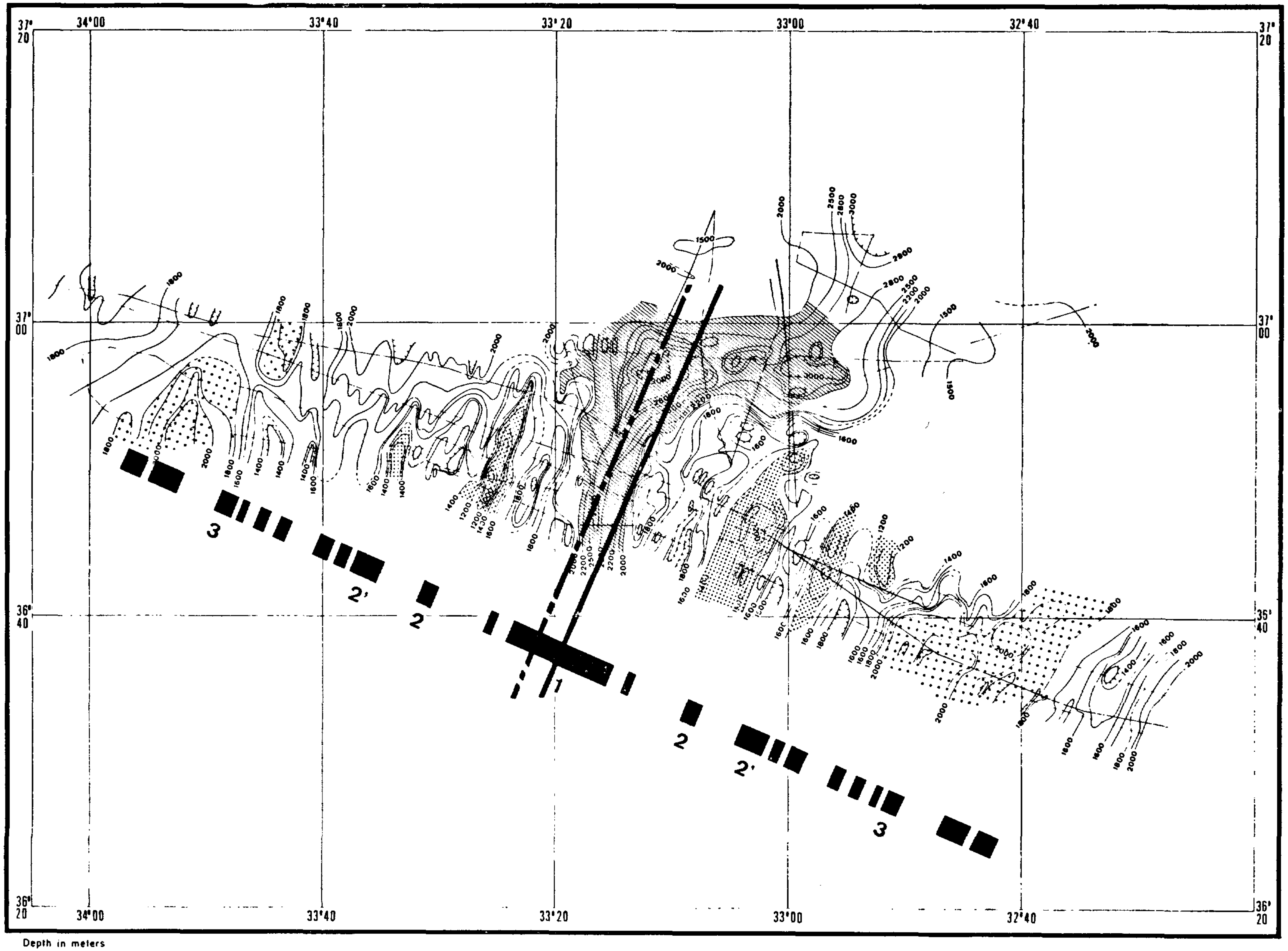

FIG. 3. — General Bathymetry of the Rift and crestal hills. Dotted line is the axis of the rift. Continuous line is the magnetic model axis. Normal polarity blocks are black, model is the same as figure 2. Rift below 2,000 m is shaded. Crestal hills are small dotted. Large 045°N trending depression is large dotted.

ding velocities computed by others in the North Atlantic [Needham and Francheteau, 1974; McDonald *et al.*, Greenewalt and Taylor, 1974].

The model show that the first well identified anomaly on both sides of the central one is anomaly 2. The pattern breaks down beyond 3 where the previous 020°N trend is intersected by 045°N trending anomalies which correspond to 3′.

Although the central anomaly is well matched by the model, one can see (fig. 3) that the axis of the corresponding magnetic block is offset from the topographic axis of the rift. The latter has been precisely defined by a narrow beam echo sounder and acoustic navigation survey [Renard *et al.*,]. Whether this axis coincides with the present rifting axis is supported by the very young ages of the rocks found on the inner floor of the central valley [Storzer and Selo, 1975].

Figure 3 also shows that bathymetric highs and lows are elongated and parallel to the rift axis. They also occupy a symmetrical position with respect to the axis of the magnetic model, and not the rift axis. This symmetry is also reflected in a one to one correspondence between symmetrical magnetic anomalies such as 2 and equivalent bathymetric features on both sides (small dots on fig. 3). The 045°N trending anomalies also correspond to symmetrical and 045°W trending bathymetric features (large dots on fig. 3). As a corollary to this observation, the offset between the rift axis and the model axis should correspond to an asymmetric rift topography. This is indeed the case [MacDonald *et al.*,]. As figure 4 shows, the rift topography inside the outer walls (1200 m) is highly asymmetric as a whole. It is made of a deep V notch valley (axis A) bordered to the east by a depressed zone or terrace with a rugged relief and lying about 800 m below the outer walls (zone B). This zone is limited to the east by a sharp cliff symmetrical with respect to the magnetic model axis to another cliff to the west. These two cliffs correspond to the inner slope of the last step of the outer walls. They coincide with the position of the Jamarillo magnetic event as predicted by the model. Indeed, the magnetic effect of the Jamarillo event, although quite limited in amplitude due to its short duration, corresponds on the observed profiles to an upward inflexion of the magnetic anomalies both east and west (marked J on fig. 4) A second high east of J is also observed but cannot correspond to Jamarillo as it is too close to east lying anomaly 2 at a 1.1 cm/yr half spreading rate. Deep-tow magnetic measurements made on the *Jean Charcot* [Greenewalt and Taylor, 1974] also show the existence of a double eastern upward inflexion both of which were associated with the Jamarillo event but no data on anomaly 2 was available at that time.

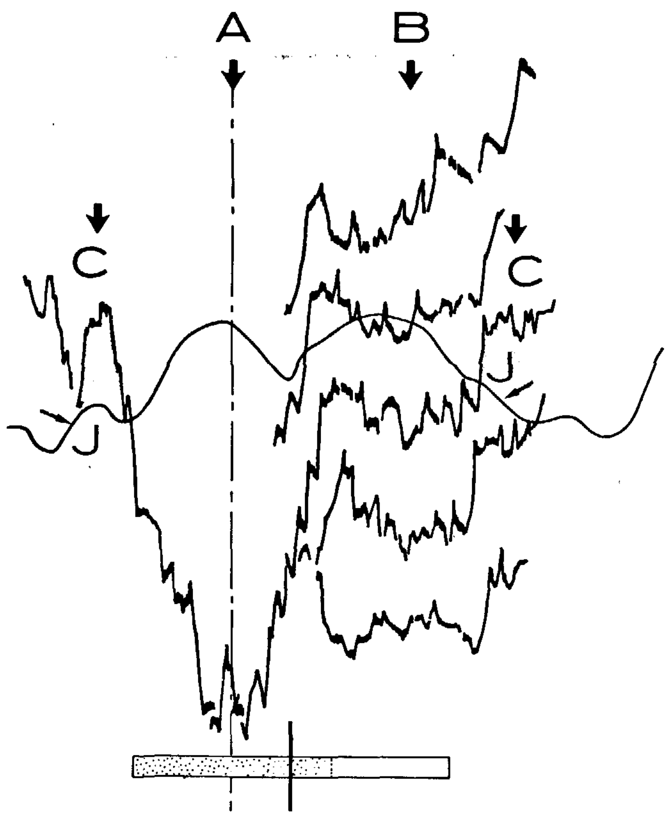

FIG. 4. — Bathymetric profile across the Rift. Several parallel profiles are shown to the east over the terrace marked B. Continuous line is the magnetic anomaly over the rift. J represents the Jamarillo event. Magnetic model is shown in the bottom. Dots represent width of accretion if A axis is choosen as rift axis. C represent the outer walls cliffs corresponding to the Jamarillo event.

Other deep two measurements [MacDonald *et al.*,] show a strong positive anomaly west of the central one in a position which corresponds to the one predicted for the Jamarillo event by our model. Thus two symmetrical anomalies associated with symmetrical topographic cliffs correspond to the Jamarillo event.

Also the Brunhes Matuyama boundary lies where the model predicts. This indicate that the central block corresponds exactly to the duration of the Brunhes normal polarity period at 1.1 cm/yr half spreading rate. The preceeding points exclude axis jumps at least before Brunhes period. Also it limits axis jumps within Brunhes to stay within Brunhes age crust otherwise total width of the central block would be greater than observed. The whole offset of axis between rift and model can therefore be limited to Brunhes period. Asymmetry is therefore limited to the section within the outer rift walls.

Two mechanisms can explain the observed asymmetry. The first mechanism is asymmetric spreading. It has been proposed by several authors [Needham and Francheteau, 1974; MacDonald *et al.*, Greenewalt and Taylor, 1974]. From our data it would amount to 0.68 cm/yr to the west and 1.52 cm/yr to the east. Asymmetric spreading would result in a slow westward drift of the accretion axis. In fact, the axis of the median valley still lies east of the axis of maximum magnetization [MacDonald *et al.*, 1975]. Two objections can be made to this mechanism. First of all, based on an argument of continuity, spreading has been symmetrical from pre-Brunhes times to at least anomaly 3 from this survey and much further beyond from other surveys [Phillips *et al.*, 1972], no apparent reasons would exist for it to become asymmetrical. Secondly, a slow westward drift of the accretion axis would create an asymmetric bathymetry. As mentionned earlier this is indeed the case if the section inside the outer walls is taken as an entity. However, if one considers, on one hand the present central inner valley below 2000 m (A on fig 4°) its deep V shaped depression has a certain degree of symmetry ; on the other hand, the eastern depressed terrace (B on fig. 4) has its deepest part located roughly in its center and could also correspond to a symmetrical feature. The whole asymmetric rift could therefore be a composition of juxtaposed symmetrical features. A westward jump of spreading axis after B formation into its present A position could therefore be a second mechanism proposed to explain the apparent asymmetry of the rift. If once in place the axis has remained fixed, the distance of the jump would be 2.7 km. This distance is deduced from geometrical elements only, it is independent of the time of the jump. Time of the jump is function of the exact location of the B depression axis. This location is hard to determine with available data. If the axis is taken at the center of the magnetic block corresponding to B, the jump would have taken place 260000 yr ago at 1.1 cm/yr spreading half rate. The jump, as seen before, cannot occur before 2.7 km of Brunhes crust has been created otherwise the axis would fall into-pre-Brunhes crust and destroy the magnetic pattern. This sets a minimum age of 245000 yr. Both values are in close agreement.

Conclusion.

Data shown led to the following conclusions. The FAMOUS zone is characterised by a symmetric spreading of the oceanic crust at a half spreading rate of 1.1 cm/yr at least up to anomaly 3′. Spreading is associated with the creation of symmetrical topographic ridges and depressions. Brunhes central anomaly although it corresponds to a normal polarity block of the right width deviates from the above due to an offset between the rift axis and the magnetic model axis. Symmetry has been destroyed either in spreading and in bathymetry or symmetry has prevailed and the central valley is only asymmetric in appearance. In the second case, the assumption of an accretion axis jump could restore symmetry but across two juxtaposed blocks.

More data, sampling (especially in B), deep-tow magnetics and other are needed to explain the observed discrepancy and to offer a better solution.

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