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THE EARTH MAGNETIC FIELD IN GRANITE BLOCKS. CUTTING PROCESS

39.1 WORLD MAGNETIC MODEL [1]

The Earth's magnetic field is mostly generated by liquid churning within the core of the planet, but the Earth is alive and magnetics poles it is been moved every year.
This information is check by NOAA and the British Geological Survey to measure and calculate predictions against the actual state of the Earth's magnetic field. Since the mid-1990s, the pace of the shift has increased from 15 kilometres per year to around 55 kilometres per year, moving from Canada to Siberia.
If we have in consideration the annual movement of the North Pole, it could be possible to think in a mobile platform into the workshop to adequate the magnetic field to the cut machines in order to avoid deviations of the cutter's utile due to the magnetic field.

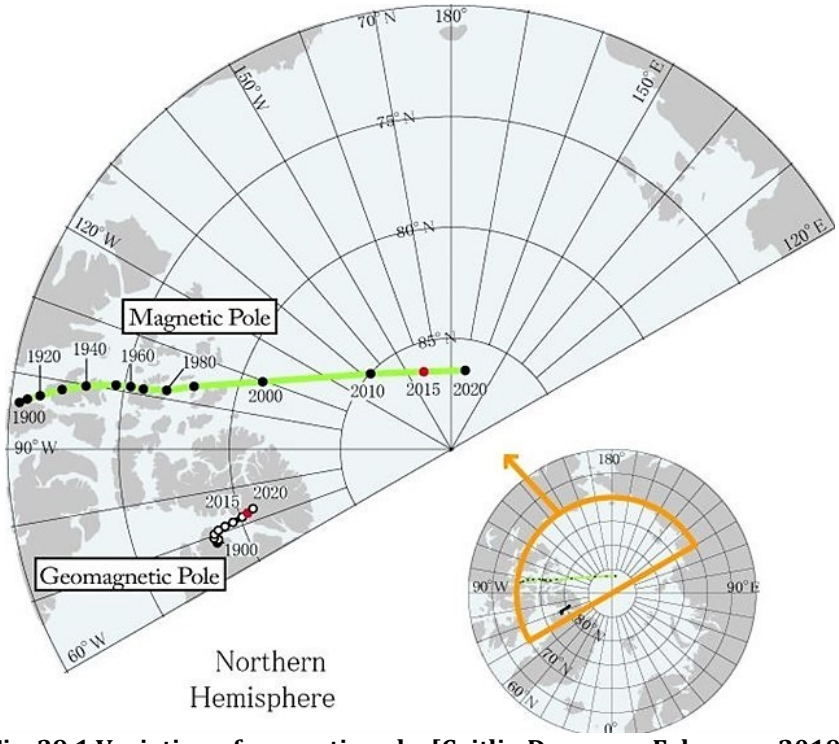


Fig. 39.1 Variation of magnetic pole. [Caitlin Dempsey. February, 2019]

On the other hand, it is amply known that metals change the magnetic field, and close to the granite cutter workshop there are many elements that introduce this kind of variation, such as electric engines, timbers, truss, other rock's looms, etc. This combination produces very important anomalies into the magnetism and must be considered to avoid deviations during the cutting process.
A tiny thickness and the great long of cutter floss, cutting saw, etc., could be produce deviations and lost utile surface granite generating more than 15% of raw material. The attraction could be reduced using "cutter-disk" due to the effect of rotation in high speed (gyroscope effect) but now, the problem is the size of the disk and heavy weight.
The example is very simple; the magnetic field direction attracts the metal of the element being used to cut granite disturbing a clean cut. These phenomena could be acquiring a great relevance if the magnetic field is perpendicular to the cut direction. Using the loom, the cut's quality decreases due to the relationship of length and thickness. The effects of the magnetic field anomalies and the impossibility to recover the original shape of the cutter saw in spite of applying strength at the end of the loom casting to stretch the strap.

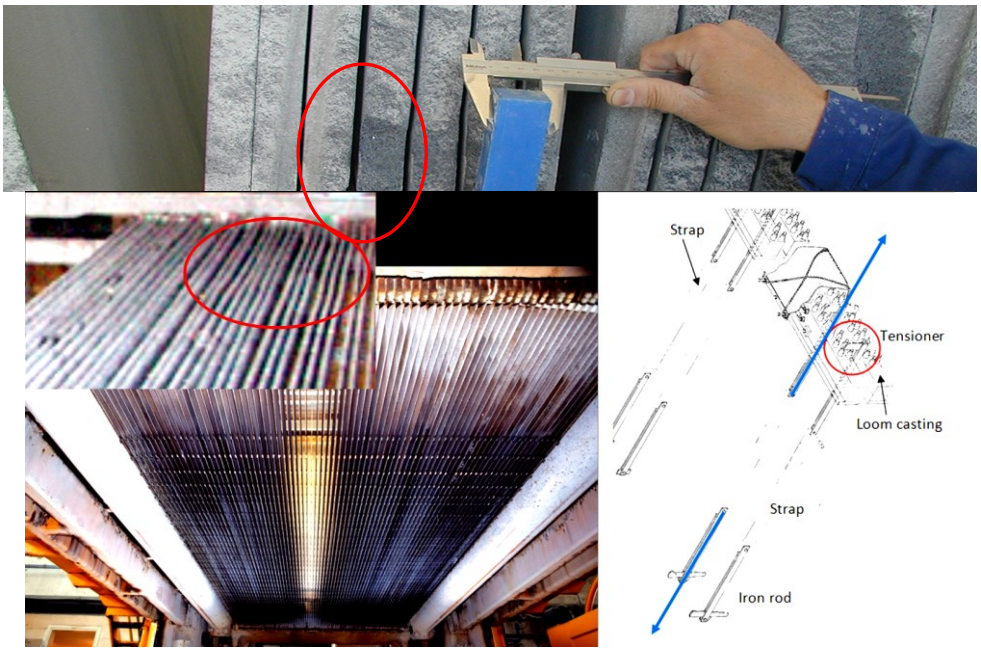


Fig. 39.2 Calibrating the thickness and defects

39.2 CALCULATING THE TOTAL CORRECTION OF A MAGNETIC FIELD

First of all, it could be interesting to prepare a blank experiment in the area, but many times it is absolutely impossible. Don't worry! We are working with a very accurate system: "The solar azimuth".
We can obtain the true solar azimuth for any date and any hour and compare this with the compass needle mark. The true bearing or course is equal to the compass bearing or course adding the total correction.

$$B_{true} = B_{compass} + C_t$$

Where total correction have two components: magnetic declination (δ_m) and compass deviation (Δ).

$$C_t = \delta_m + \Delta$$

The first term could be calculated using the World Magnetic Model (WMM) or testing a blank experiment in a place near the workshop area but no affected by metals ($\Delta = 0$).

UT	SOL SD: 16,2′ PMG: 12h 13,1m			
	hG ⊙		Dec	
h	°	′	°	′
0	176	42,6	−9	16,8
1	191	42,7		15,8
2	206	42,8		14,9
3	221	42,9		14,0
4	236	43,0		13,0
5	251	43,1	−9	12,1
6	266	43,2	−9	11,2
7	281	43,3		10,3
8	296	43,4		09,3
9	311	43,5		08,4
10	326	43,6		07,5
11	341	43,7	−9	06,5
12	356	43,8	−9	05,6
13	11	43,9		04,7
14	26	44,0		03,8
15	41	44,1		02,8
16	56	44,2		01,9
17	71	44,3	−9	01,0
18	86	44,4	−9	00,0
19	101	44,5	−8	59,1
20	116	44,6		58,2
21	131	44,7		57,2
22	146	44,8		56,3
23	161	44,9		55,4
24	176	45,0	−8	54,4

Fig. 39.3 Nautical Almanac

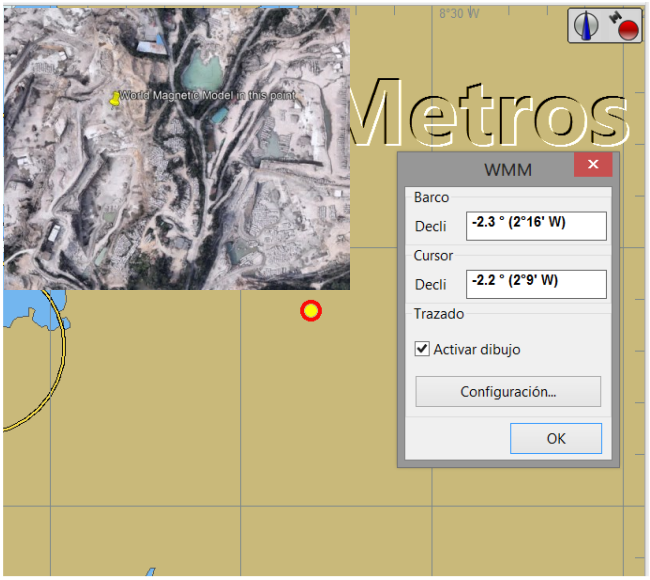


Fig. 39.4 WMM. World Magnetic Model. Open CPN

The total correction change depending of the position of metal objects into the magnetic field. For this reason, a deviation table on 16th different courses must be considered.

To obtain the total correction values (C_t) respect the true North, we compare the compass and solar azimuth and C_t = *True solar azimuth – compass mark course*.

You must consider the signs (East +, West -) in quadrantal or azimuth value in circular mode (0^0-360^0) commonly known as nautical azimuth and Northern hemisphere (+) and Southern hemisphere (-).

First of all, the "*Sun's triangle of position*" must be calculated using mathematics algorithms.

The angle P = [HL☼] if the sun position is Western and P = 360^0 - [HL☼] if Eastern.

[HL☼] is the local time of the sun or the clockwise angle from the observer to the star.

P (time angle), is always less than 180 degrees, and must be considered the time in Greenwich of the Sun [HG☼] = [HL☼] + L

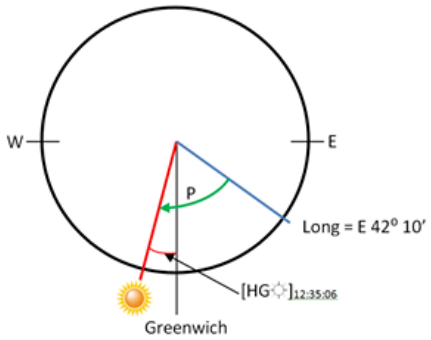


Fig. 39.5 Local Hour

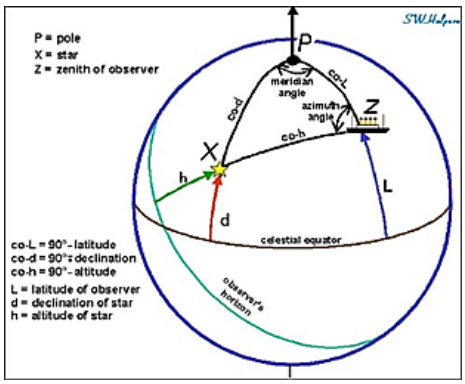


Fig. 39.6 Spherical triangle

Example: Calculate the local time of the Sun and solar azimuth for February, 25th 2019 at 12:35:06 UTC in a place with latitude = N 60^0 35' and Longitude = E 42^0 10'.

The time in Greenwich of the Sun [HG☼], could be calculated by interpolation using a Nautical Almanac or programing the solar equations into a Calculator or Spreadsheet.

a) Nautical Almanac [4]**:**

a1. *Local Time and declination at 12:35:06.*

$[HG☼]_{12h} = 356^0\ 43.8'$ and $[HG☼]_{13h} = 11^0\ 43.9'$

In one hour, the difference is:

$\Delta[HG☼] = (360^0 + 11^0\ 43.9') - 356^0\ 43.8' = 15^0\ 0'\ 6''$ (speed of the Sun between 12h to 13h).

$[HG☼]_{12:35:06} = [HG☼]_{12h} + \Delta[HG☼] \bullet (0h\ 35'\ 06'') =$

$[HG☼]_{12:35:06} = 365^0\ 30'\ 21.51'' = 5^0\ 30'\ 21.51''$ (The Sun is at West of Greenwich).

The local time [HL☼] *is:*

$[HG☼]_{12:35:06} = [HL☼]_{12:35:06} + L \rightarrow 5^0\ 30'\ 21.51'' = [HL☼]_{12:35:06} + (-42^0\ 10')$

remember that the Sun's time is always clockwise direction (+West) and Longitude is (- East).

$[HL☼]_{12:35:06} = 5^0\ 30'\ 21.51'' + 42^0\ 10' = 47^0\ 40'\ 21.51''$ and the ☼ observation is West.

$P = [HL☼]_{12:35:06} = 47^0\ 40'\ 21.51''$ at west of me.

The Sun declination (Dec δ) could be calculated by interpolation like the Hour of the Sun in Greenwich:

$\delta_{☼12h} = -9^0\ 5.6'$ and $\delta_{☼13h} = -\ 9^0\ 4.7'$

In one hour the Sun decline $\Delta\delta = -\ 9^0\ 4.7' - (9^0\ 5.6') = 0^0\ 0'\ 54''$

$\delta_{☼12:35:06} = \delta_{☼12h} + \Delta\delta \bullet (0h\ 35m\ 6s) = -9^0\ 5.6' + (0^0\ 0'\ 54'') \bullet (0h\ 35m\ 6s)$

$\delta_{☼12:35:06} = -9^0\ 5'\ 4.41''$

a2. *Calculating the Sun' azimuth (Z) using Bessel's Formula to solve the spherical triangle.*

Now we are ready to calculate the azimuth using a cotangent formula:

$\text{ctg}\ Ø_\delta \bullet \text{sen}\ Ø_l = \cos Ø_l \bullet \cos P + \text{sen}\ P \bullet \text{ctg}\ Z$ where:

$Ø_\delta$ = Codeclination $= 90^0 - \delta = 90^0 - (-\ 9^0\ 5'\ 4.41'') = 99^0\ 5'\ 4.41''$

(*) Note. Discussion of sign:

- ✓ If δ is the same name than observation hemisphere, codeclination is always 90^0 - ABS (δ)
- ✓ If δ is different name than observation hemisphere, codeclination is always 90^0 + ABS (δ)

Example: Name of observation hemisphere South (-), Star's declination South (-). Codeclination is 90^0-ABS(δ).

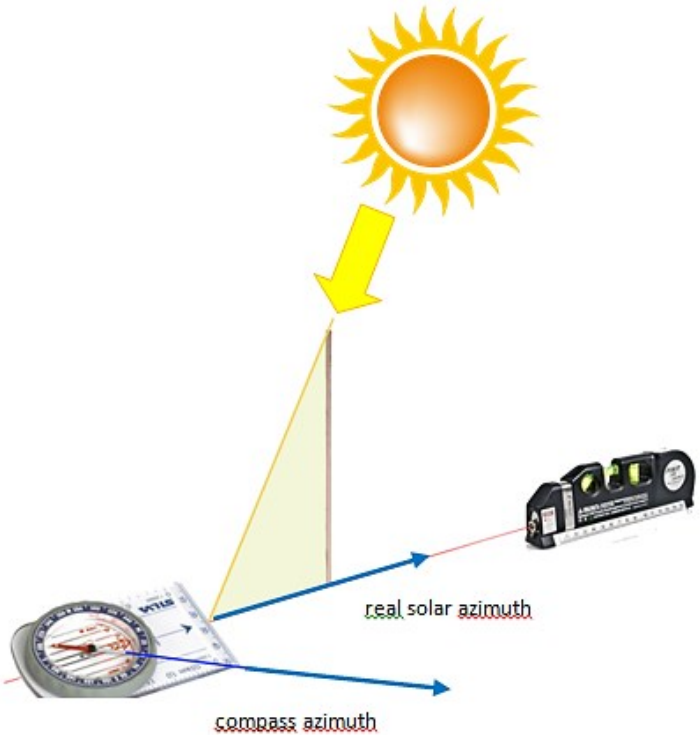
$Ø_l$ = Colatitude $= 90^0$ - latitude $= 90^0 - 60^0\ 35' = 29^0\ 25'$

P = Polar angle = $47^0\ 40'\ 21.51''$

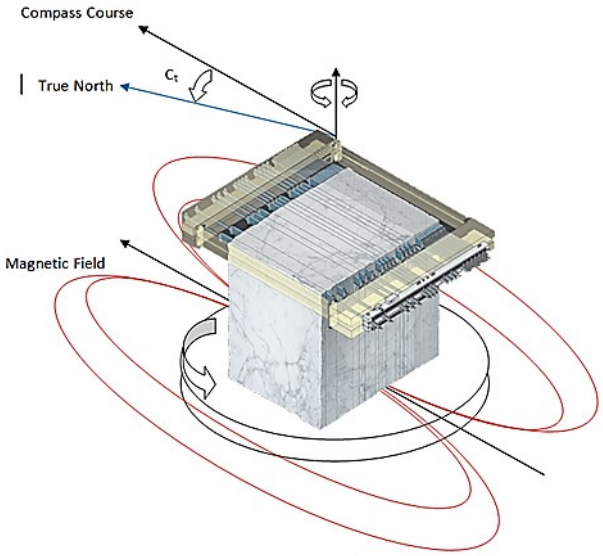
Z = Azimuth

$$Z = \arctan\left[\frac{\sin P}{\frac{\sin \emptyset_l}{\tan \emptyset_\delta} - \cos \emptyset_l \cos P}\right] = -48^0\ 1'\ 31.45"$$

The results are in quadrantal mode. Discussion:
We are in Northern hemisphere (+) and Z is (-) we need to change (+ x - = -). Z is Southern and orientation is west because the Sun position is at west of me.
Z = South 48^0 1′ 31.45" West = **228^0 1' 31.45"**
Step three. *How to calculate the total correction in the experiment at 12:35:06 or other any hour?*



To reproduce the experiment we must consider:
1) horizontal flat area
2) vertical stick to project the Sun's shadow
3) laser level to project the light over the floor soil
4) compass
5) clock chronograph
Experiment:
The true or real Sun's local azimuth at 12:35:06 is 228^0 is the laser light-line aligned with the shadow.
Now, we can align the longitudinal compass axis with laser light and read the compass value. For instance:
Compass reading = 243^0
Difference (Total correction Ct) = 228^0 - 243^0 = -15^0 or 15^0 NW (*Northwest*)



It is just the result or how many degrees increase or decrease the magnetic field due to the presence of metals in this place.
The blank experiment let you to know the variation of magnetism and compare the readings out and into the workshop.
The granite block must be aligned with the magnetic field to improve the cutting results avoiding magnetic attraction.

b) Using a calculator or spreadsheet to obtain the solar parameters [1].

First of all, it is important to comment, that the accuracy of this method is enough for us in spite of not consider the attraction effects of different planets and moon.

b1. *Calculating the Julian Day for February, 25th 2019 at 12:35:06*

JD_{0h} = 2458539.5 T_{0h} = 0.191498973

$JD_{12:35:06}$ = 2458540.024 $T_{12:35:06}$ = 0.191513330

b2. *Calculating the time of Aries (♈) in Greenwich Θ_0 at 12:35:06*

[HG♈] = 343^0 51’ 46.75”

b3. *Calculating coordinates*

Geometric Sun’s mean Longitude L_0 = 7175.093781

λ_{0m} = 335^0 5’ 37.61”

M (anomaly m) = 51^0 49’ 37,56”

Eccentricity of the Earth’s orbit e = 0.016700579

Sun’s equation of the centre C = 1.523966462

True Longitude ☉ = 336^0 37’ 3.89”

True anomaly υ = 53^0 21’ 3.84”

Radius vector R = 0.989854499

Apparent Longitude λ = 336^0 36’ 27.26”

b4. Calculating s*olar ecliptic*
Obliquity = 23^0 26' 12.48"
Corrected obliquity = 23^0 26' 8.64"

b5. *Equation of Time*
Eq_t (^{0} degrees) = -3.271297798^0
Eq_t (Minutes) = -13.08519119'

b6. *Calculating Right Ascension (R.A.) 180^0*
R.A. = -21^0 38' 52.19"

b7. *Calculating Sidereal angle (S.A.) and R.A.(360^0)*
S.A. = 21^0 38' 52.19"
R.A. = 338^0 21' 7.81" (22h 33m 24.42s)

b8. Calculating the *Time of the Sun in Greenwich* [HG☼] *and declination* (δ)
$[HG☼]_{12:35:06}$ = 5^0 30' 38,94"
$\delta_{☼12:35:06}$ = -9^0 5' 7.05"

b9. *Calculating the Local Time of the Sun* [HL☼]
$[HG☼]_{12:35:06} = [HL☼]_{12:35:06}$ + L ➔ 5^0 30' 38,94" = $[HL☼]_{12:35:06}$ +(-42^0 10')
$[HL☼]_{12:35:06}$ = 47^0 40' 38.94" = P

b10. *Solving the spherical triangle*
$Ø_δ$ = Codeclination = 90^0 - δ = 90^0 - (-9^0 5' 7.05") = 99^0 5' 7.05"
$Ø_l$ = Colatitude = 90^0 - latitude = 90^0 - 60^0 35' = 29^0 25'
P = 47^0 40' 38.94"

$$Z = \arctan\left[\frac{\sin P}{\frac{\sin Ø_l}{\tan Ø_\delta} - \cos Ø_l \cos P}\right] = -48^0\ 1'\ 46.74"$$

Solar azimuth: **South** 48^0 1' 46.74" **West =** 228^0 1' 46.74"
The experiment is the same.

REFERENCES

1. Astronomical algorithms (Second Edition). Jean Meeus. ISBN 0-943396-61-1
2. Trigonometría esférica. Fundamentos. Unidad docente de matemáticas. Universidad Politécnica de Madrid. Manuel Barrero Ripoll, Mª Luisa Casado Fuente, Mª Angeles Castejón Solanas, et al. ISBN 84-96244-13-X
3. Capitán de Yate. Juan B. Costa. ISBN 978-84-937355-5-5
4. Almanaque náutico 2017. Ministerio de Defensa. Real instituto y Observatorio de la Armada en San Fernando. NIPO: 083-15-062-7. ISSN 0210-735-X
5. Variation of magnetic pole. Caitlin Dempsey. February, 2019

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THE EARTH MAGNETIC FIELD IN GRANITE BLOCKS. CUTTING PROCESS

Abstract: This document reports on the problem of magnetic fields during the preparation of granite blocks. The most prominent problem consists of the use of long, thin cutting tools by which the magnetic field introduces detours in the cutting-process, losing more than 15% of granite block as raw material. In order to avoid or minimize the effects of magnetic fields, the magnetic orientation of the industrial building must be considered and the true deviation produced by the field must be calculated. On the contrary…, what happen when the workshop is built without magnetic considerations?. First of all we need to know and separate the effects of fields. In marine terms, this problem consist of calculating the total correction due to the effects of true magnetic field (δ_m) and deviation (Δ). Like a vessel navigating around the earth, the true course is the addition of two terms: compass course (magnetic) and effects of total correction ($\delta_m + \Delta$) where it is produced by the total metal mass around me and δ_m is the magnetic field of the earth in this point.
We are going to calculate the total correction (c_t).

Key words: Cutting-process of granite blocks. Effects of magnetic fields in granite blocks. Total magnetic corrections in a workshop

ZIEMSKIE POLE MAGNETYCZNE W CIĘCIU BLOKÓW Z GRANITU

Streszczenie: Niniejszy artykuł dotyczy zagadnienia pól magnetycznych w przygotowaniu bloków granitowych. Największym problemem podczas obróbki bloków granitowych jest gdy pole magnetyczne ma wpływ na proces ich cięcia i wprowadza zniekształcenia w tym procesie powodując 15% strat w postaci odpadu granitu. Dzieje się tak podczas stosowania narzędzi tnących o dużej długości i małej grubości. Aby zminimalizować wpływ pól magnetycznych, należy wziąć pod uwagę orientację pola magnetycznego w budynku przemysłowym i obliczyć rzeczywiste odchylenie wytwarzane przez to pole. Ale ... co się dzieje, gdy warsztat został zbudowany bez uwzględnienia kwestii magnetycznych? Po pierwsze, konieczne jest poznanie i rozdzielenie efektów pól. W kategoriach morskich problem ten polega na obliczeniu korekcji całkowitej ze względu na wpływ pola magnetycznego (δ_m) lub deklinacji magnetycznej i odchylenia (Δ). Podobnie jak statek płynący wokół Ziemi, prawdziwym kierunkiem jest dodanie dwóch terminów: kursu igły (magnetyczny) i efektów całkowitej korekty ($\delta_m + \Delta$), gdzie Δ jest wytwarzana przez całkowitą masę metalu wokół mnie i δ_m jest polem magnetycznym Ziemi w tym punkcie. Zamierzamy obliczyć całkowitą korektę (ct).

Słowa kluczowe: Proces cięcia bloków granitowych, wpływ pola magnetycznego, całkowite poprawki magnetyczne w warsztacie

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